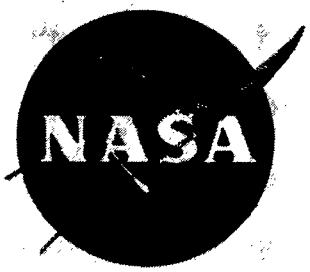
NASA CR-111999

PRELIMINARY TEST PLAN

DEFINITION STUDY FOR AN EXTENDED MANNED TEST OF A REGENERATIVE LIFE SUPPORT SYSTEM

November 1971



Prepared under Contract No. NAS1-10790
by the Biotechnology and Power Department
Advance Systems and Technology
McDonnell Douglas Astronautics Company
Huntington Beach, California

For

Langley Research Center

NATIONAL AERONAUTICS and SPACE ADMINISTRATION

FOREWORD

A Definition Study for Extended Manned Testing of a Regenerative Life Support System has been conducted by the Biotechnology and Power Department of the McDonnell Douglas Astronautics Company (MDAC), Huntington Beach, California, under Contract NAS1-10790. This project was performed for the NASA-Langley Research Center under the direction of Mr. C. W. McKee of the Space Systems Division.

The program was supervised by K. H. Houghton, M. D., Chief Advance Technology Engineer of the Biotechnology and Power Department, MDAC. J. K. Jackson was the Program Manager for McDonnell Douglas. Assisting him were J. R. Wamsley, M. D., Test Medical Director; M. S. Bonura, Test Engineering Director, and J. S. Seeman, Crew Integration Director.

This report was prepared under the direction of J. K. Jackson with major assistance from:

M. S. Bonura
J. R. Wamsley, M. D.
J. S. Seeman
G. E. Allen
P. P. Mader, Ph.D.
N. A. Jones
H. B. Kelly, Ph.D.
D. J. Myers
G. L. Murphy, Ph.D.
D. F. Putnam
E. R. Regis
R. V. Singer
R. E. Shook
Mary Sofios
J. P. Valinsky
M. M. Yakut

The results of this study are presented in the following reports:

NASA CR-112000, (MDAC G2624) Final Report
NASA CR-111999, (MDAC G2625) Preliminary Test Plan

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

FIGURES

FIGURES (Continued)

TABLES

Section 1

INTRODUCTION

As part of the development of the technology required to support future long-duration manned space missions, a selected contractor will conduct an Extended Manned Test of a Regenerative Life Support System. This document presents a preliminary plan and procedure for conducting this program, which was developed by MDAC under Contract NAS1-10790, a Definition Study of an Extended Manned Test. Emphasis for this test will be placed on elements associated with long-term system operation and long-term uninterrupted crew confinement.

1.1 PROGRAM OBJECTIVES

The general objective of the program is the evaluation of advanced regenerative life support subsystems, and to perform such auxiliary studies that will assist in obtaining this evaluation, or that may economically be performed concurrently, thus enhancing the value of the program. In meeting this general objective, the following detail objectives have been established:

A. Expand the technology for advanced[1] regenerative life support systems and obtain data on performance, operating characteristics, maintainability, and subsystem interactions.

B. Investigate and evaluate concepts and techniques of systems automation in the areas of monitor and alarm, fault isolation, automatic checkout, and parametric feedback control which may be applied to life support systems.

---

1 For the purposes of this report, an advanced subsystem is defined as a subsystem or unit of improved design of a type which has not undergone previous extended manned testing.

C. Develop techniques for monitoring the status of equipment, health and morale within the vehicle, minimizing the requirement for outside laboratory support and eliminating the need, whenever possible, for passing out samples from the chamber.

D. Perform selected Earth-orbital experiments and evaluate onboard and external support requirements.

E. Perform mission planning and provide the necessary equipment and procedures to establish crew task requirements that are realistically representative of in-flight experiments and operational needs, to evaluate the man-systems interfaces, to properly assess the equipment capabilities in supporting the crew, and to maintain the crew morale by assigning meaningful work.

F. Evaluate the effects of the closed environment on the physiological and psychological status of the crew.

G. Obtain data and trends on chemical and microbial characteristics in the closed environment.

H. Demonstrate human performance in a simulated operational space vehicle environment.

I. Define and evaluate new methods of improving space vehicle habitability.

1.2 PROGRAM ORGANIZATION

The program organizational structure established by the test conductor is to be described in this section. It is recommended that this organization should include the following functions as shown on Figure 1-1, or equivalent:

The Program Manager will be delegated the authority and will be held responsible by senior management to accomplish program objectives. He is to be the sole line of authority for direction and control of the program organization and serves also as the principal point of contact with NASA for exchange of technical information.

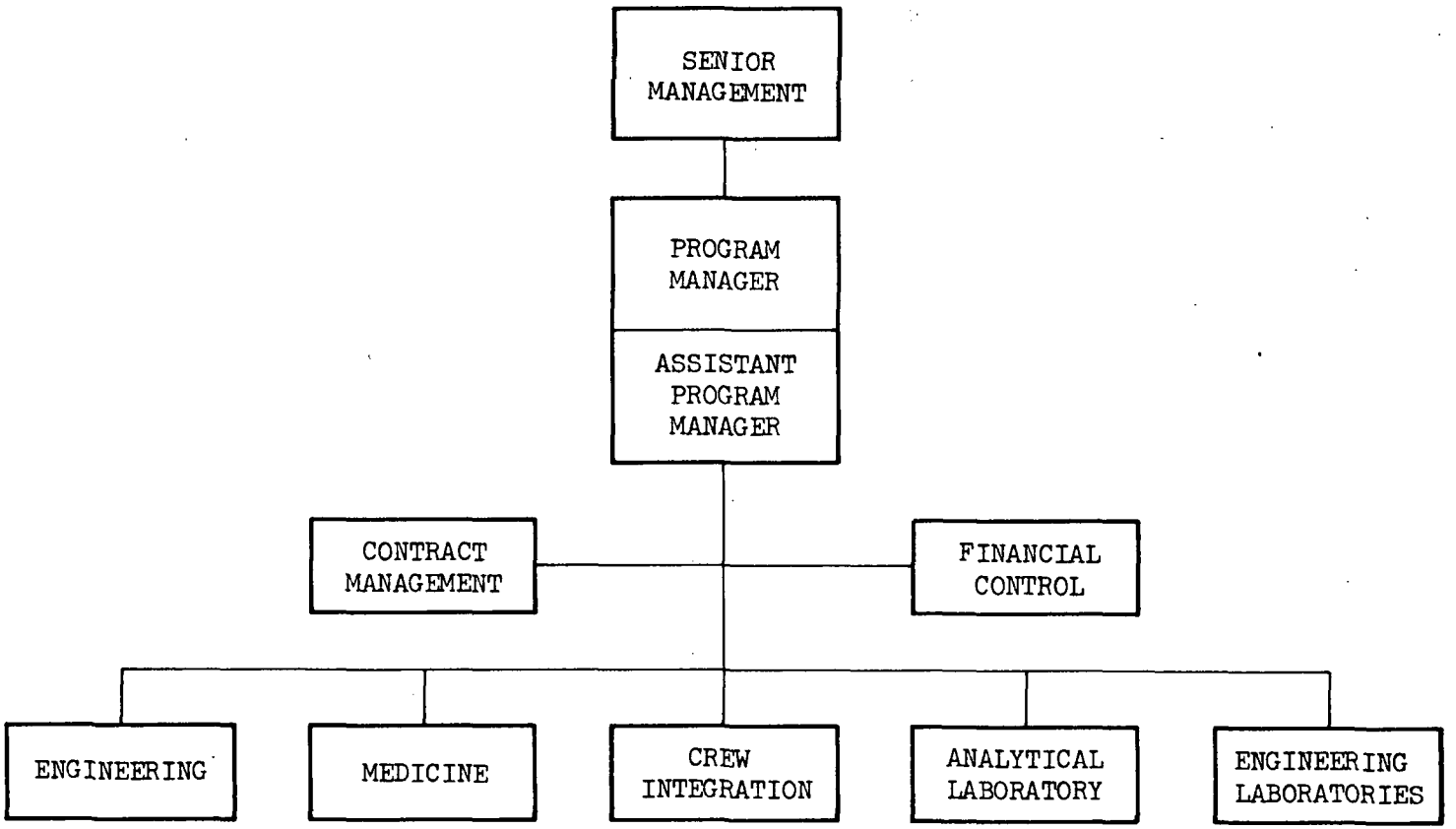


FIGURE 1-1. RECOMMENDED ORGANIZATION FOR EXTENDED MANNED TEST

The Assistant Program Manager will act for the Program Manager in the event of his absence. He may also serve in one of the technical director functions such as Test Engineering Director, Test Crew Integration Director, or Test Medical Director, whose functions are described below. It is recommended that his technical background complement that of the Program Manager.

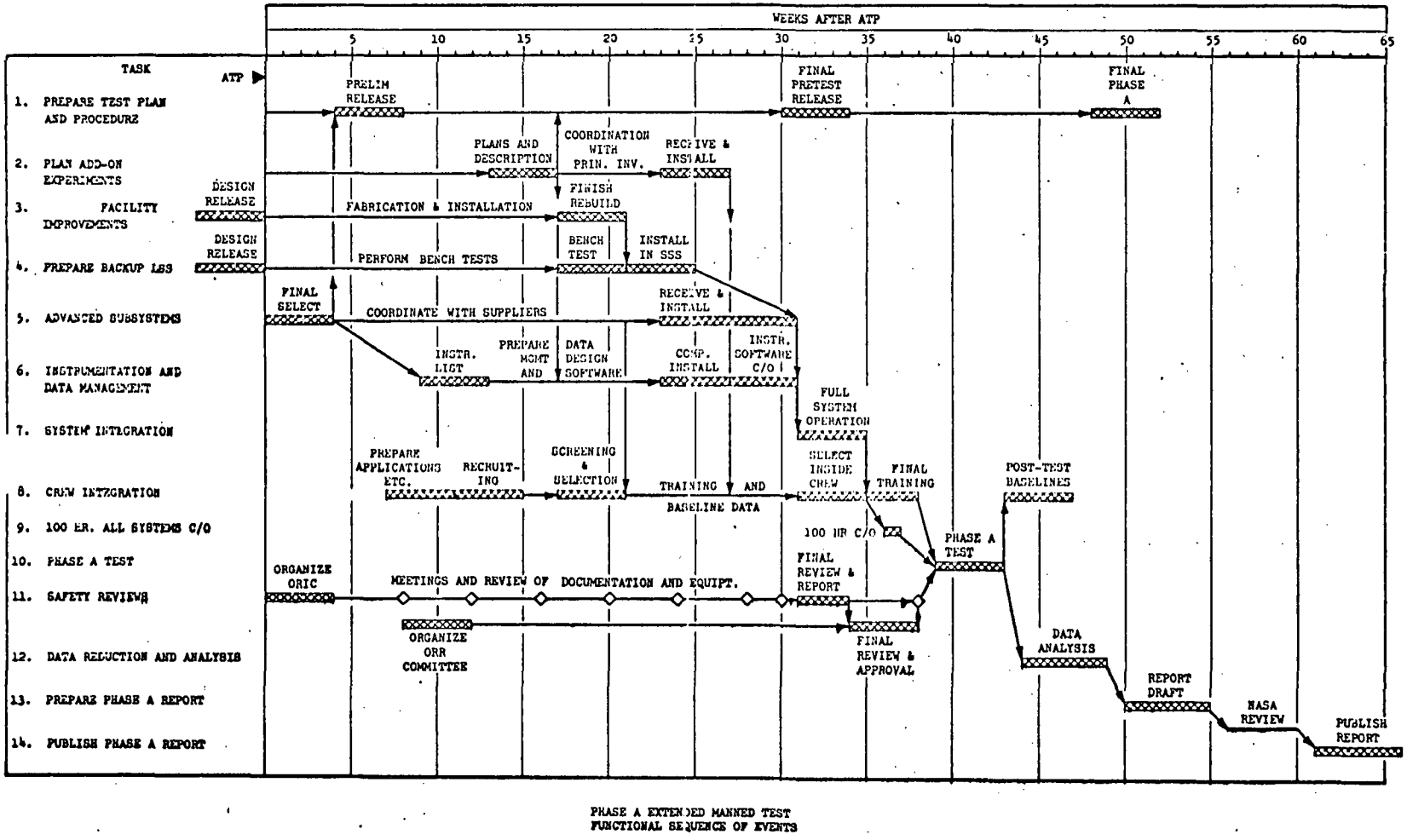
The Test Engineering Director will manage the engineering aspects of the test including supervision of the Engineering staff during system design, drawing release, fabriction, change control of drawings and other documents, test operations, and report preparation. He will coordinate with other test directors and provide necessary assistance to them in performance of their tasks.

The Test Medical Director will have overall cognizance of the medical aspects of the program and will provide the functions required of the Medical Officer as defined in Paragraph 10 of Reference 1. He will also provide day-to-day direction to the scientific team including microbiologists, physiologists, etc.

The Test Crew Integration Director will be responsible for crew selection and training, habitability features of design, behavioral studies, and other man/systems aspects of the program.

The Test Analytical Laboratories Director will be in charge of the chemical analysis of atmosphere and water samples and material selection procedures and criteria. The analysis of biomedical samples may be assigned to him or to the Test Medical Director.

The Test Engineering Laboratory Director will direct the technicians who fabricate, install, and service the test facility and equipment; and such engineers as may be required to provide adequate supervision. He will provide liaison between the program organization and the test contractor's laboratory organization.



PHASE A EXTENDED MANNED TEST
FUNCTIONAL SEQUENCE OF EVENTS

FIGURE 1-2. PROGRAM SCHEDULE

The Program Manager should also be provided with staff assistance for financial control and contract management functions.

1.3 PROGRAM SCHEDULE

The projected Program Schedule is shown in Figure 1-2.

1.4 OPERATIONAL READINESS INSPECTION (ORI)

An Operational Readiness Inspection Committee shall be constituted in accordance with the test contractor's internal requirements for safety review of manned tests (if any) and to fulfill the functions required by Reference 1. This Committee will present results of their review to the Program Manager, the contractor's senior management, and the Operational Readiness Review Committee constituted by NASA-LaRC. It is recommended that the ORI board consist of a chairman, secretary, flight surgeon, safety officer, inspection and test reliability representative, mechanical engineer, and an electrical engineer. Advisory members may include representatives from the legal and employe relations departments and NASA-LaRC.

The ORI review is scheduled for completion just prior to the 100 hour manned test (see Section 12.2). A second ORI prior to the extended manned test will be conducted if the results of the 100 hour test warrant it.

1.5 TEST PLAN AND PROCEDURE

It is recommended that the test plan and procedure should be updated throughout the life of the program. A change control procedure similar to that outlined in Reference 2, Section 1.5, should be used.

Section 2

SUMMARY DESCRIPTION AND OPERATING CONDITIONS

The plan for the manned test is summarized in this section. The program description represents the implementation of NASA-LaRC Statement of Work L18-1886.

2.1 MANNED TEST CONDITIONS AND REQUIREMENTS

In order to assure mission realism and complete crew isolation during the continuous manned test, the airlock passthrough port will not normally be used. An autoclave is incorporated into the airlock passthrough port to provide for sterilization if passthrough operations are required.

All crew equipment and expendables will be stored onboard to maintain mission requirements without passin. Passin or passout operations will not be conducted unless authorized by the Program Manager and the NASA Technical Representative.

The LSS will maintain the following nominal atmospheric conditions:

Total Pressure (O_2 and N_2)	103.3 $\pm$ 2.0 kN/m^2 (775 $\pm$ 15 mmHg)
Oxygen Partial Pressure	20.7 $\pm$ 0.67 kN/m^2 (155 $\pm$ 5 mmHg)
Cabin Temperature	294 $\pm$ 2.8°K (70 $\pm$ 5°F)
Relative Humidity	40 to 70 percent
CO_2 Partial Pressure	400 N/m^2 (3 mm Hg)

In the event of operation outside these values, adherence to the procedures defined in Section 3.6 will be maintained.

2.2 MASS BALANCE PROCEDURE AND PREDICTION

The mass balance data for the extended test will be presented in three separate segments identified as:

1. Average Crew Input/Output Data
2. Water Management Mass Balance
3. Gaseous Mass Balance

Details of the equipment, procedures and instrumentation pertinent to this section are contained under applicable headings in the body of this document.

2.2.1 Average Crew Input/Output Data

The extended manned test average crew input/output data will be presented as shown in Figure 2-1. The values shown in Figure 2-1 represent the daily averages to be expected during the test. The final report will contain the actual values.

2.2.2 Water Management Mass Balance

Figure 2-2 represents the reporting format for the water management mass balance. Figure 2-2 contains the daily average values to be expected during the test for the primary operating mode only. Secondary operating modes are represented by an arrow and the figure (2). The post-test configuration of Figure 2-2 will present the actual values and days of operation, and will define any deviations from the primary operating mode with the appropriate mass balance values.

2.2.3 Gaseous Mass Balance

Figure 2-3 represents the reporting format for the gaseous mass balance. The daily average values represent the primary operating mode only. The secondary operating mode is defined with an arrow and the figure (2). The test report will contain Figure 2-3 with actual total cumulative values,

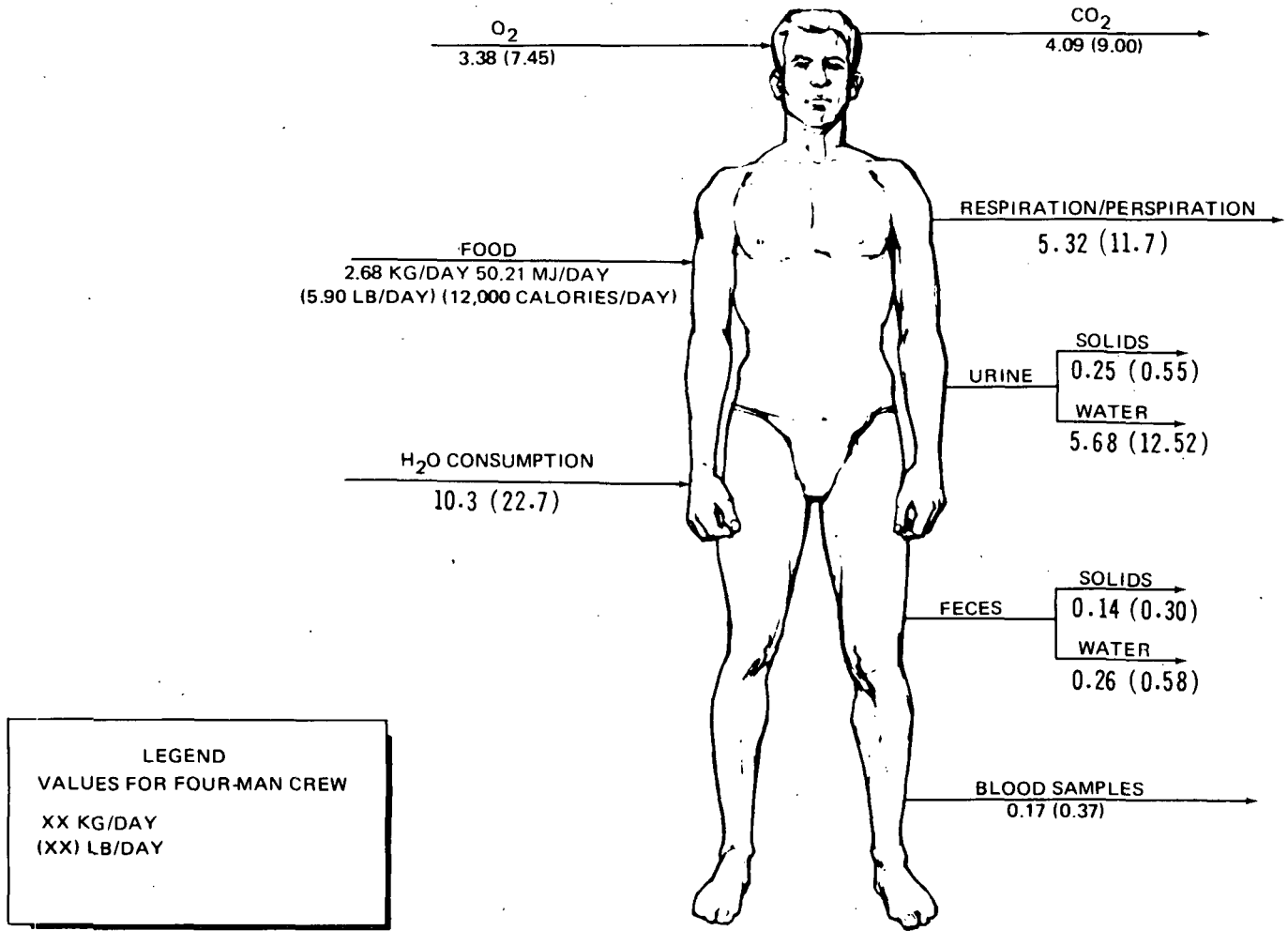


FIGURE 2-1. AVERAGE CREW INPUT/OUTPUT DATA

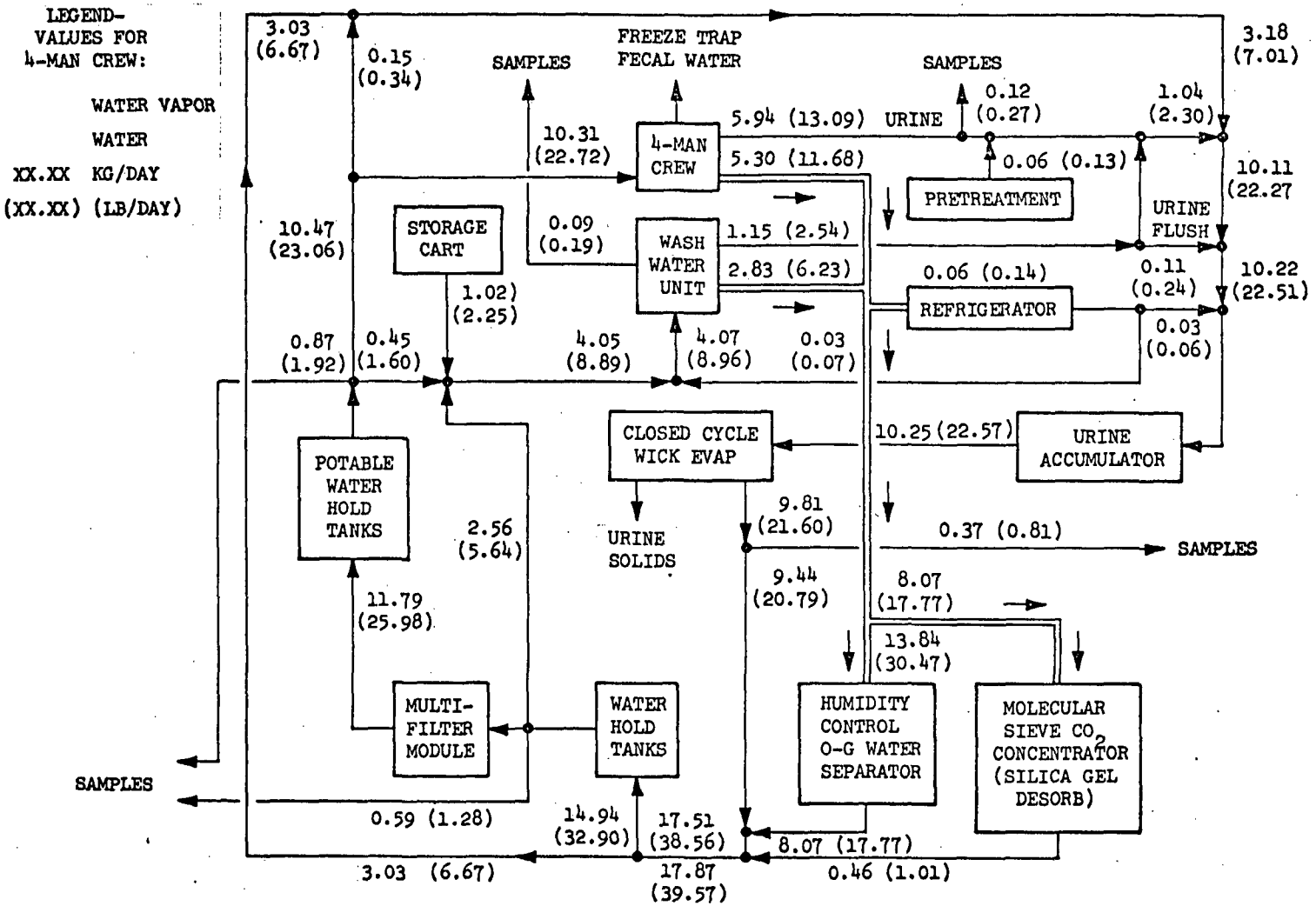


FIGURE 2-2. BASELINE WATER MANAGEMENT MASS BALANCE

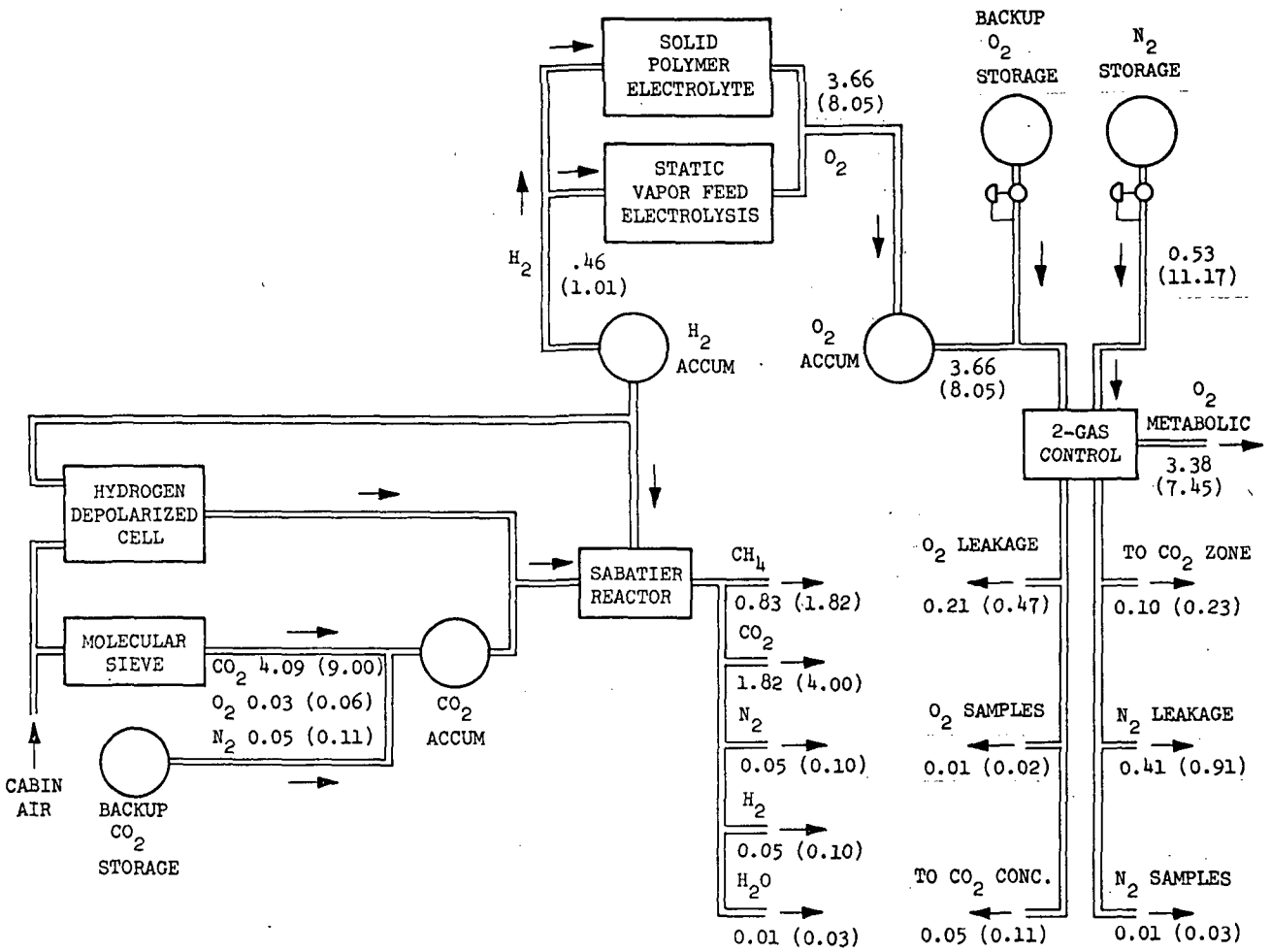


FIGURE 2-3. GASEOUS MASS BALANCE

daily averages, period of operation and will define any deviation from the primary operating mode with the appropriate mass balance values.

2.3 THERMAL BALANCE

The thermal balance is to include the equipment producing or removing heat inside the test chamber. A tentative list is shown in Table 2-1. Figure 2-4 represents the planned reporting format for the thermal balance. The values shown represent the expected values for the primary operating mode. If operation of a secondary mode is required such as activation of the molecular sieve CO_2 concentrator unit in place of the advanced CO_2 concentrator unit, the overall thermal balance shown in Figure 2-4 would change because of the variance in the thermal operating characteristics of the two units. Figure 2-4 will be presented in the post-test report showing the variations in the actual thermal balance during all modes of operation. Section 4 contains a detail description of the thermal system and its operation.

2.4 ELECTRICAL POWER USAGE

The electrical hardware to be incorporated into the chamber will be designed to use one or more of the following power forms: 115 vac, 60 Hz, single phase; 120/208 vac, 400 Hz, three-phase; and 28 vdc. Details of the electrical power distribution are given in Section 4.

A preliminary list of the power requirements for the test electrical equipment is shown in Table 2-2. The post-test report will include details of the actual power requirements for the test. Also included will be system power load profiles obtained through the data acquisition system.

2.5 QUALITY ASSURANCE (QA) PLAN

The purpose of the program QA plan is to insure:

1. Documentation of material and configuration control
2. Control of workmanship, quality, and safety
3. Verification of installations and operation of equipment, components, systems, and instrumentation

TABLE 2-1

LIFE SUPPORT EQUIPMENT INVOLVED IN THERMAL BALANCE

EQUIPMENT	HEAT PRODUCING			HEAT REMOVAL	
	ELECTRICAL	LATENT	SENSIBLE	LATENT	SENSIBLE
HYDROGEN DEPOLARIZED CELL	X	X	X	**	
MOLECULAR SIEVE UNIT	X		X	X	
SABATIER AND TOXIN	X	X	X	X	
WICK EVAPORATOR	X			X	X
LIGHTING AND RECREATION	X				
CREWMEN		X	X		
MISCELLANEOUS UNITS	X				
WASH/POT WATER STORAGE	X				
REFRIGERATOR/FREEZER	X		X	X	
HOT PROCESS FLUID LINE LOSS			X		
THERMAL/HUMIDITY CONDITIONING UNIT	X				X
ELECTROLYSIS	X	*		*	X

NOTES: *LATENT HEAT PRODUCTION TO BE REMOVED BY CONDENSERS WITHIN UNITS.
**LATENT HEAT TO BE PARTIALLY REMOVED BY CONDENSER WITHIN UNIT.

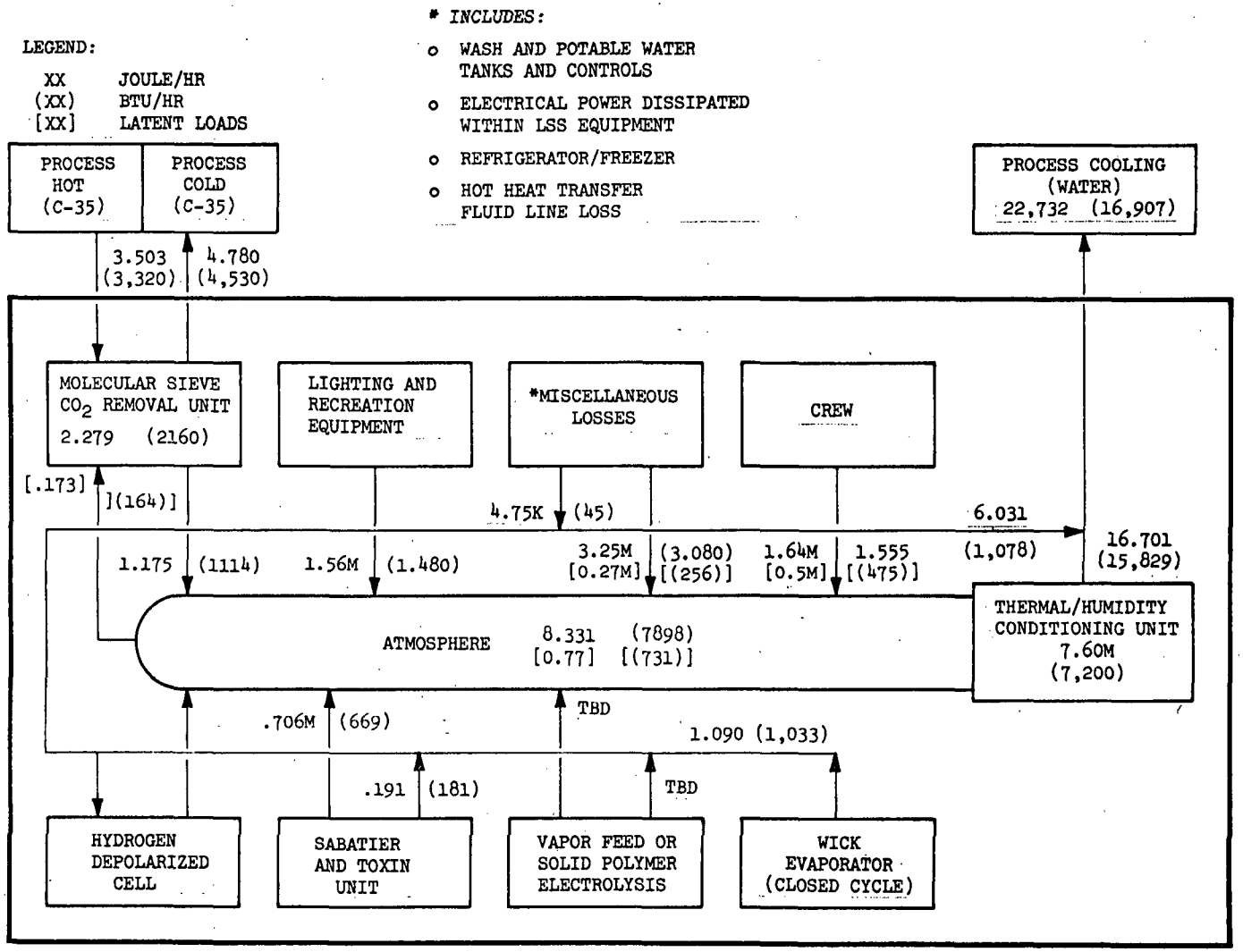


FIGURE 2-4. TYPICAL OVERALL THERMAL BALANCE

Table 2-2 POWER REQUIREMENTS FOR SSS

POWER SOURCE	SUBSYSTEM/UNIT	COMPONENTS	AVERAGE PWR (WATTS)*
60 Hz 115 VAC 1 PHASE	WASH WATER	TWO TANK HEATERS TWO PUMPS	240.9
	POTABLE WATER	SIX TANK HEATERS WICK EVAPORATOR PREHEATER TWO PUMPS ELECTRO-CHEM PRETREATMENT	725.2 TBD
	THERMAL CONTROL	CIRCULATING PUMP CONTROLS	1,000.7
	MOLECULAR SIEVE	1 VACUUM PUMP CONTROLS	394.7
	H_2 DEPOLARIZED CELL		TBD
	ELECTROLYSIS		287.5 Δ
	SABATIER AND TOXIN		10.2
	HOUSEKEEPING	LIGHTING, BIOMED, ETC.	756.3
	TWO-GAS CONTROL		32.8
400 Hz 120/208 VAC 3 PHASE	WICK EVAPORATOR	BLOWER	306.3
	THERMAL CONTROL	BLOWERS (2)	2,368.3
	MOLECULAR SIEVE	1 BLOWER	255.0
	COMMODE	**	756.3
28 VDC	ELECTROLYSIS	1 STATIC VAPOR FEED SOLID POLYMER ELECTROLYTE	1,454.2 TBD
	OTHER USES INSIDE CHAMBER	*	139.9

NOTES: *ALL SUBSYSTEMS INCLUDE SMALL INTERMITTENT DC LOADS FOR CONTROLS.
**COMMODE OPERATION INCLUDES INTERMITTENT 400 Hz POWER.
Δ ESTIMATED
(1) BACKUP COMPONENTS

4. Certification of all checkout operations including both pre-runs and post-runs
5. Inventory control
6. Accomplishment of all Operational Readiness Inspection Committee (ORIC) chits
7. Equipment certification control.

The procedure that will be followed to implement the above plan is outlined in the following 15 paragraphs:

1. A master QA book will be provided for the overall program. This book will consist of, but will not be limited to:

   a. Work Request Orders

   b. Contract specifications

   c. QA plan

   d. Design requirements (reference: Appendix F)

   e. Procurement Engineering Orders (EO's)

   f. Material compatibility index (ref: Section 6.2.1 and Design Requirements Specification, Appendix F)

   g. Master drawing index

   h. ORIC chit index

2. Two QA documentation books will be provided - one for the chamber and one for facilities. Both books will be of identical formats consisting of the following as a minimum:

   a. ORIC chits

   b. Equipment status log

   c. EO index and EO's

   d. Q. C. Record Card

   e. Removal and Installation card

   f. Inspection Item Sheet (IIS)

   g. Failure and Rejection Report (FARR)

   h. Fabrication Order (Outline)/Assembly Outline

   i. Open item recap log

   j. Pre-flight inspection and sign-off

   k. Post flight inspection

3. Material control will be maintained as specified in Section 6.2.1. A limited amount of combustibles (e.g., cards, games, books) will be allowed on-board the test chamber with control maintained by an Inventory Drawing.

4. Q. C. Record Card will be utilized to document a running activity log and sequential inspection.

5. All instrumentation will be verified and checked out per the Instrumentation Drawing.

6. All design and drawing requirements will be as specified in the LSS Manual. (reference: paragraph 5.5)

7. Verify status of all ORIC chits and verify accomplishment of all mandatory ORIC chits.

8. Any item, once installed and recorded in the Quality Assurance log book, will not be removed, modified, reworked, etc. without proper authority (e.g., released Engineering Order) and with the full knowledge and concurrence of Quality Assurance.

9. Combustible seals or identification tags will be kept to a minimum and will be controlled under paragraph 3 above.

10. All operations included in Sections 12, 13 and 14 must be witnessed by Quality Assurance and properly documented.

11. Upon satisfactory completion and checkout of the test facilities, Quality Assurance will provide a signed turnover statement, listing any open items or other anomalies, stating that the test is ready for operation to the Program Manager. The Program Manager will sign to accept the operation. In addition, certified copies of Pre-test Inspection Checkouts by Quality Assurance and the Program Manager will be placed in the Master Test Plan.

12. During the actual run, Quality Assurance will monitor the test and facilities on a daily basis. This survey will consist of verification of all released EO changes; removal and installation of facility items, instrumentation, equipment and maintenance items per the facilities manual; scrutinizing the simulator for safety items and the accumulation of waste and combustionables; and verify test conductor's log.

13. At the completion of the 100-hour manned test, conduct a post-run check of simulator and facilities for damage and maintenance items.

14. Prior to extended manned test, repeat, as applicable, paragraphs 3 through 12.

15. At the completion of the extended manned test, conduct a post-run check of simulator and facilities for damage and maintenance items.

16. A list of internal documents that support the Quality Assurance Plan of this program is to be inserted here, as in Reference 2, Section 2.6.

Section 3

MANNED TEST OPERATIONS

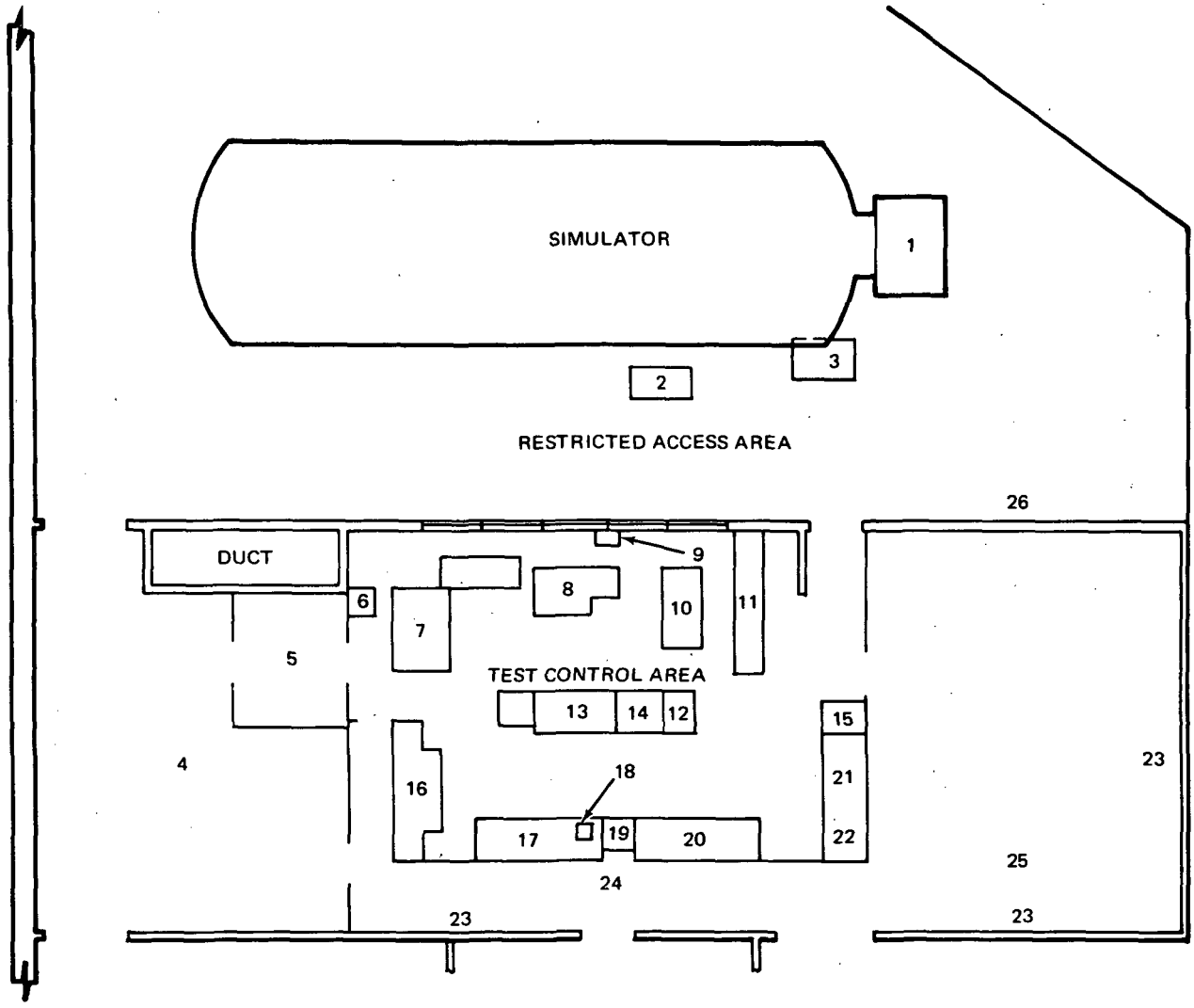
This section defines test operations philosophy; responsibilities of the operating staff, support staff, and crew; normal, contingency, and emergency procedures; and safety rules.

3.1 TEST OPERATIONS PHILOSOPHY

All operating plans, procedures, and rules shall be oriented to support the objectives of the integrated manned test; and to insure crew safety and health during the operation and detailed evaluation of advanced regenerative life support subsystems and during the performance of tasks realistically representative of operational requirements and in-flight experiments. To accomplish this end, the crew shall be permitted that flexibility needed to reschedule crew events to permit their performance during any given day of the test. Priority shall be given to all operating staff requests which pertain to the monitoring, adjustment, maintenance, or repair of any life support subsystem or component.

3.2 OPERATING STAFF

The operating staff shall administer the test in accordance with provisions of this test plan. Test coverage shall be provided 24 hours a day by personnel certified in accordance with requirements defined in Section 8. Each shift, as a minimum, shall consist of a Test Conductor, Medical Monitor, Communications Monitor, Engineering Monitor, and Electrical/Mechanical Technician. Staff Members may be replaced during the test only by certified alternates and with approval of the Program Manager. The shift/rotational schedule for the Medical Monitor may deviate from that established for other staff members due to unique support and monitoring requirements. The test control area layout shall be similar to that shown in Figure 3-1.



1. PLATFORM/RAMP
2. GAS ANALYZER
3. LOCK CONSOLE
4. GAS CHROMATOGRAPHY LAB
5. MEDICAL MONITOR
6. TIME LAPSE VIDEO RECORDER
7. COMMUNICATIONS CONSOLE
8. TEST CONDUCTORS CONSOLE
9. SMOKE DETECTOR ALARM
10. DESK
11. PATCH PANEL (REF)
12. TIME SHARE COMPUTER TERMINAL
13. TABLE
14. PSYCHOMOTOR ELECTRONICS AND TESTERS
15. TAPE RECORDER
16. LIFE SUPPORT MONITOR CONSOLE
17. LOW SPEED DIGITAL SUBSYSTEM CONSOLE
18. COLD TRAP RECORDER
19. URINE RECORDER
20. PHYSIOLOGICAL DISPLAY SUBSYSTEM CONSOLE
21. ANALOG MEASUREMENT SUBSYSTEM CONSOLE
22. ERGOMETER MEASURING EQUIPMENT
23. MISSION DISPLAYS
24. VISITORS AREA
25. CONFERENCE AREA
26. EMERGENCY MEDICAL TREATMENT EQUIPMENT

FIGURE 3-1. TEST CONTROL AREA

3.2.1 Test Conductor

The Test Conductor shall be responsible for the operation of the simulator and overall function of the staff. He reports directly to the Program Manager or, in his absence, to the Assistant Program Manager.

The Test Conductor's console controls the normal operational functions of the facility, as well as emergency operations. The Test Conductor will man his station at all times, except during an Emergency Test Operation as noted in Section 3.6.4 and except for short periods of time during his shift when he may be relieved by the Engineering Monitor.

3.2.2 Medical Monitor

The Medical Monitor shall be a qualified physician licensed to practice medicine in California. He shall be responsible for monitoring the health of the crew and for advising the Test Conductor on crew status. He shall remain at all times in the Medical Monitor location, in the Operations Area, or in the immediate vicinity of the test chamber.

3.2.3 Communications Monitor

The Communications Monitor shall be responsible for the audio-visual operation of the console and related equipment and for all crew communications. He will also be responsible for the day-to-day monitoring of crew timeline accomplishment, and for advising the Test Conductor of any abnormal conditions within the simulator.

The Communications Monitor shall man the Communications Console at all times except when relieved for short periods of time during his shift by the Engineering Monitor.

3.2.4 Engineering Monitor

The Engineering Monitor shall be responsible for the operation of the Airlock Console, monitoring of the LSS, and the acquisition of all engineering data pertinent to the test operations and for advising the Test Conductor of any abnormal condition within the test chamber. He shall be trained and certified to act as a temporary operator at the Test Conductor and Communications Monitor Consoles.

3.2.5 Technician

The mechanical or electrical technician shall provide maintenance of the test facility and support equipment. Technicians shall receive training and certification in accordance with job classification requirements and the provisions of Section 8.

3.3 SUPPORT STAFF

Cognizant support personnel will be on duty during normal day-shift working hours and on call at all other times to provide assistance to the operating staff in the areas of electrical-mechanical engineering, safety engineering, contamination control, microbial control, quality assurance, electrical and mechanical equipment maintenance and repair, and crew activity scheduling.

3.4 CREW

The crew shall consist of four men, one of whom is designated Crew Commander. They will be responsible for the performance of all events included in the Crew Activity Schedule; for the performance of all unscheduled activities necessary for the maintenance, repair, and operation of on-board equipment; and for the performance of all unscheduled activities necessary to insure crew health and safety.

3.4.1 Crew Commander

The responsibilities of the Crew Commander will include crew task allocation, safety monitoring, evaluations of onboard crew performance, coordination with program management on subsystems problems, assistance in crew selection, and crew morale assessment and management.

The Crew Commander will be responsible for implementation of the daily scheduled crew activities with authority to change the schedule to accomplish all events. Concurrence for deletion of scheduled events must be obtained from the Test Conductor. Assistance in crew activity rescheduling required as a result of contingency or an excessive burden of unscheduled activities shall be provided by the operating staff upon request.

Onboard crew organization shall be a quasi-military chain of command. A deputy commander will be designated by the commander with approval of the Program Manager. The function of the deputy will be identical to that of the commander during periods when the commander is unavailable (e.g., commander's sleep period), and as required by the commander at other times.

During continuous manned test operations, the commander will report directly to the Test Conductor and/or the Program Manager, as appropriate.

3.4.2 Crew Members

Crew members shall be responsible to the Crew Commander for accomplishment of daily scheduled events and to the Test Conductor for accomplishment of all unscheduled events. Priority will be given to Operating Staff requests which pertain to the monitoring, adjustment, maintenance, or repair of any life support subsystem or component.

3.5 ACTION PHONE LIST

An Action Phone and Address List shall be maintained at the Test Conductor's console for use at the discretion of the Test Conductor on a 24-hour-a-day basis. Emergency notification procedures are included in Section 3.6.4. The following personnel, as a minimum, will be on the Action Phone List:

Program Manager*
Medical Director*
Consultant Physician
Engineering Director*
Crew Integration Director*
Engineering Laboratory Test Coordinator*
Safety Engineer*
NASA Resident Technical Director*
Principal Investigators on each subsystem group or experiment

* These personnel, whose functions are related to operating safety, must keep the Test Conductor informed of their whereabouts on a 24-hour-a-day basis, or provide a suitable alternate who will be available.

3.6 TEST RULES AND OPERATING PROCEDURES

This section defines general rules and procedures for normal test operations, contingency test operations, and emergency test operations.

3.6.1 General Rules

Release of test information to the general public must be cleared in accordance with established procedures.

One clock in the Test Control Area shall be designated as the official test time standard. All references to test time during the test will use the standard test time clock. The clock on the Crew Life Support Console inside the simulator will be synchronized with the standard test time clock daily during the test.

One operating staff member at a time may be absent from the test control area for short periods of time during manned test operations with the following limitations: 1) Staff members will sign in and out using the Test Conductor's Log, 2) The Medical Monitor must not leave the test operations building, 3) The Test Conductor's Console and the Communications Console must be manned at all times, except as noted in Section 3.6.4.

The crew will be permitted as much flexibility as possible for scheduling and performance of events to be accomplished during any one day of the test. A Crew Activity Schedule, covering each day of the test, will be provided to both the crew and operating staff. The Crew Commander shall be responsible for implementation of the daily crew assignments with authority to change the schedule as required to accomplish all events. The Test Conductor must approve the deletion of a scheduled event. A Crew Event Priority List, such as that in Table 3-1, will be provided to both the Crew Commander and the Test Conductor for use as an aid in any rescheduling activity.

Crew initiated communications will not be limited. Operating and support staff personnel will restrict communications to test activities and in all

Table 3-1

CREW EVENT PRIORITY LIST

Categories:	Priorities:
Eng. -- engineering activity Med. -- medical activity M/S -- man/system activity	1 -- No delay permissible 2 -- Reschedule with specified maximum delay 3 -- Reschedule within same work shift 4 -- Omit if required 5 -- Omit if necessary

Event	Priority Category	Comments
Safety inspection	1 Eng.	
Urine sample	1 Med.	
Monitor instruments	1 Eng.	
Cabin cleaning	2 M/S	24-hour delay permissible
Habitability evaluation	2 M/S	48-hour delay maximum
Laundry	2 M/S	24-hour delay maximum
TV camera maintenance	2 M/S	24-hour delay maximum
Sleep	2 Med.	Maximum limits set by either individual crewmen or medical monitor
Water samples/tests	2 Med.	2-hour maximum
Spirometer	2 Med.	24-hour delay
Switch water tanks	2 Eng.	2-hour delay maximum
Blood tests	2 Med.	2-hour maximum delay
Bacteria sample count	3 Med.	
Exercise	3 Med.	

Table 3-1 (continued)

Event	Priority Category	Comments
Medical interview	3 Med.	
Station Atmosphere samples	3 Med.	
Food Consumption data	3 Eng.	
Mass balance data collection/ reporting	3 Eng.	
Mass spectrometer verification	3 Eng.	
Bed linen change	4 M/S	
Body hygiene-wash	4 M/S	
Breakfast	4 M/S	Snacks may be substituted
Lunch	4 M/S	May substitute snacks if necessary
Dinner	4 M/S	Snacks may be substituted
Psychomotor test	4 M/S	
Diary	4 M/S	Do not permit two consecutive omissions
Photography	4 M/S	Reschedule at crew discretion
Biomedical checks	4 Med.	
Blood samples	4 Med.	Do not omit twice in succession
Station surface samples	4 Med.	
Sleep log	5 M/S	
Snack	5 M/S	

instances will conduct the communications in a businesslike manner. During contingency operations, operating staff personnel will direct the crew as required in accordance with procedures contained in Section 3.6.3.

The Communications Monitor shall insure audio privacy between the physician and crew member during medical interviews and between the psychologist and crew member during behavioral interviews.

The crew shall not intentionally mask a TV camera lens or turn off a TV camera without permission of the Communications Monitor unless the action is scheduled as an event in the Crew Activity Schedule. When necessary, the crew shall delay performing these events to insure they take place during the time of low activity to preclude loss of significant data.

No one, except on-duty operating staff members or their replacements at shift change time, shall be permitted within the test operations area without the permission of the Test Conductor on duty or the Program Manager. It shall be the responsibility of the Test Conductor to limit such permission and to clear authorized personnel when their tasks are completed in order to maintain orderly operations.

The Communications Monitor will insure that interference with scheduled crew free-time periods is minimized by: (1) assuring that requests from the outside staff for unscheduled maintenance or instrument monitoring are evaluated and approved by the Test Conductor prior to transmitted instructions to the crew and (2) delaying all other requests until the end of the scheduled crew free-time period, as appropriate.

3.6.2 Normal Test Operations

Normal test operations and the staff's function and responsibilities listed below may be augmented with special functions during the run as necessary to accomplish the requirements of this test plan when directed by the Program Manager. The staff's basic function and responsibilities in conducting normal manned test operations shall be as follows:

1. Test Conductor
   a. Overall test and staff operational responsibility.
   b. Operation of the Test Conductor's console.
   c. Insure intershift Test Conductor's overlap.
   d. Maintain, by shift, the Test Conductor's Log.
   e. Keep the Program Manager informed as to the status of the test and inform him immediately of any abnormal condition.
   f. Maintain the Action Phone List in a current status.

2. Medical Monitor
   a. Overall responsibility for the crew health and test medical protocol as defined in Section 9.
   b. Acquisition of test medical data.
   c. Notify the Test Conductor and Medical Director of any abnormal conditions or potential hazard to the health or safety of the crew.
   d. Maintain, on a shift basis, the medical log.

3. Communications Monitor
   a. Overall crew/staff, audio/video communications responsibility.
   b. Operation of the Communications Console and, as required, the TSCL.
   c. Acquisition of video-recorded data.
   d. Notify the Test Conductor of any abnormal conditions.
   e. Notify the Crew Integration Director of any abnormal crew behavior.
   f. Maintain, on a shift basis, the Man/Systems Log.

4. Engineering Monitor
   a. Overall responsibility for operation of LSS, related engineering experiments, and support equipment.
   b. Operation of the Air Lock Console.
   c. Operation and monitoring of the LSDS, LSM, and TSCL.
   d. Acquisition of all engineering data.
   e. Act as standby operator for the Test Conductor's Console and Communications Monitor.
   f. Maintain, on a shift basis, the Engineering Monitor's Log.

5. Electrical/Mechanical Technician
   a. Assist the Engineering Monitor, as required.
   b. Monitor and maintain facility supporting equipment, as required.
   c. Monitor and maintain recording equipment expendables.
   d. Notify the Test Conductor of any abnormal conditions.
   e. Maintain, on a shift basis, the Technician's Log.

6. Crew Members/Crew Commander
   a. Perform all scheduled events.
   b. Perform unscheduled events as requested.
   c. Assist the Crew Commander in rescheduling of Crew Activities.
   d. Notify the Test Conductor of any abnormal conditions.
   e. Maintain, on a daily basis, all technical and personal logs.

3.6.3 Contingency Test Operations (CTO)

Contingency test operations shall be initiated by the Test Conductor in the event of abnormal test conditions that do not activate emergency test operations, as defined in Section 3.6.4, such as a system/partial system malfunction, medical problem, smoke alarm, a trace contaminant buildup, or the inability of the test to meet major program objectives. This mode of operation will provide for the unscheduled use of procedures and cognizant personnel to correct situations that may affect the crew health and safety or test objectives. Unscheduled test termination is also provided for under CTO. In the event of CTO, it shall be the responsibility of the Test Conductor to immediately notify the Program Manager , all the staff/crew members, and other applicable personnel as required on the Action Phone List and to provide for the acquisition of data to document conditions. The Program Manager will notify the NASA Resident Technical Director as soon as possible of the existence of any CTO condition. The various modes of operation under CTO and the responsibilities of the crew and staff are described in Reference 2 , Section 3.4.2. A separate step-by-step sequence of each staff member's function during the "off normal" operations will be posted during manned testing.

3.6.4 Emergency Test Operations (ETO)

Emergency test operations shall be declared by the Test Conductor when any abnormal condition requires the use or activation of emergency test equipment (see Section 6). Emergency test operations are divided into three categories - Test Conductor's ETO, medical ETO and fire abort ETO. The Test Conductor's and medical ETO are time-phased procedures utilizing emergency and supporting equipment as required to provide maximum safety for the crew consistent with varying conditions. The fire abort ETO is an automatic operation used only in the event of a fire when conditions do not allow for planned staff/crew reaction time. A step-by-step sequence of each staff member's function during the "off normal" operations will be posted during manned testing.

A description of each of the three categories of Emergency Test Operation (ETO) conditions is given in Reference 2, Section 3.4.3.

Upon declaring an ETO, the notification procedure shown in Figure 3-2 will be initiated by the Test Conductor. Copies of Figure 3-2 shall be posted prominently in the Test Operations area and provided to all personnel who will be involved in the Emergency Notification Sequence. Names, in-plant phone extensions, and home phones for all personnel involved will be included in these copies.

In accordance with established operating procedures, no employe shall make any statements to any person about details of the program during or following any ETO condition, except to other staff members or as authorized by the Emergency Notification Sequence.

3.7 SAFETY RULES

The safety rules are divided into three categories: Pretest Safety Rules to be prominently posted inside and at the entrance to the simulator during the pretest phase of the program, Manned Test Safety Rules to be prominently posted in the staff control area and restricted access area (see Figure 3-1); and Crew Manned Test Safety Rules to be observed inside the test chamber during manned testing.

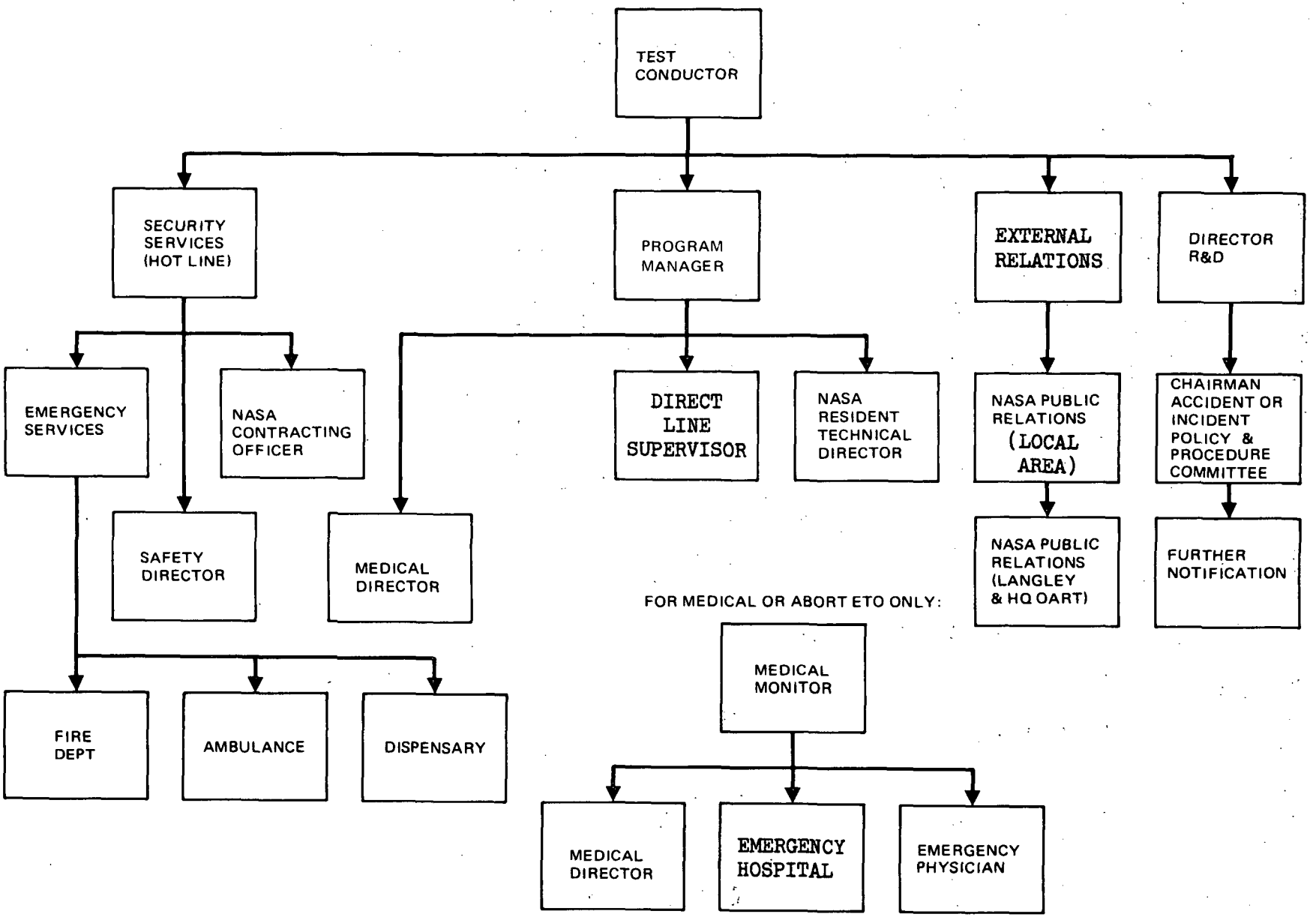


FIGURE 3-2. EMERGENCY NOTIFICATION SEQUENCE

These three categories of safety rules are defined in Reference 2, Section 3.5.

3.8 PRIMARY/BACKUP UNIT CONTINGENCY PLAN

A primary/backup unit contingency plan must be developed for diagnosing major failures, evaluating their effect, and planning corrective action. This plan shall provide a summary of quickly available information to the test operations crew, as well as a statement of operating policy regarding repair of a primary subsystem or activation of a backup unit.

The basis for this plan is the FMECA discussed in Section 7.1. The definitions of class of failure correspond with those used in Section 7.1 and are as follows:

Class	
1	Fatal to one or more crew members.
2	Imminent test termination.
3	Correction required or possible test termination will result if alert levels are exceeded.
4	Alternate, backup system utilized or corrective maintenance required.
5	System performance degradation without requirement for correction.

A typical primary/backup contingency plan is shown in Reference 2, Table 3-2.

Section 4

TEST FACILITY

The test facility is to consist of a closed chamber and equipment necessary to evaluate a four-man crew and their life support systems under simulated orbital space station conditions.

This section describes a typical simulator configuration and facility requirements for the extended manned test.

4.1 CHAMBER

A test chamber, similar to that described in Reference 2, Section 4.1, is to be provided.

4.2 SPACE VACUUM SIMULATION

A vacuum simulation system similar to that described in Reference 2, Section 4.2, is to be provided for performance of the extended manned test.

4.3 THERMAL SIMULATION

The thermal subsystem includes the heating and cooling fluid facilities and the associated valves, switches, pumps, filters, and indicators for fluid flow rates, temperatures, and pressures. The instrumentation details for thermal conditioning are defined in Section 11.

The cooling and heating requirements for the life support and environmental control subsystems are fulfilled by two fluid conditioning and transport units. The cooling fluid facility provides coolant at 274°K (34°F) to 278°K (40°F). The fluid heating facility provides fluid at 422°K (300°F)

to 436°K (325°F) to the carbon dioxide concentrators. Figure 4-1 is a schematic block diagram of the thermal subsystem showing the interface between the cooling and heating fluid facilities and the subsystems which use the cooling and heating fluids.

The cooling fluid facility is located outside the simulator and consists of an insulated storage tank, two redundant Freon refrigeration systems to cool the coolant, a circulation pump for each system to force coolant through the evaporator coils and back to the storage tank; and an external plumbing system, with two pumps in parallel, to supply the coolant to the simulator and return it to the storage tank. These parallel pumps provide redundancy to ensure high reliability. Shutoff valves are provided to permit independent operation of either pump. A regulating bypass valve controls the pressure of the delivered fluids.

The heating fluid facility is also located outside the simulator and includes an insulated storage tank, an immersion heater within the tank to heat the fluid, a powerstat to control the voltage to the heater, a thermostat to control the temperature of the coolant within the storage tank, a circulation pump, plumbing to supply the fluids to the test chamber, a vent, and an overflow tank. Shutoff and bypass valves are located at the tank and at the pump to facilitate servicing and to regulate flow.

4.4 ELECTRICAL POWER

The electrical power subsystem for the test includes 60 Hz, 115 vac, 1 phase; 400 Hz, 120/208 vac, 3 phases; and 28 vdc. Power usage will be recorded by watt-hour meters on each 60-Hz circuit, watt meters on each 400-Hz circuit, and ammeters and voltmeters on the dc circuits. Automatic recording of power data will be provided by power sensors on groups of the ac circuits and a shunt in the dc circuits. These signals will be recorded on the digital data collection subsystem.

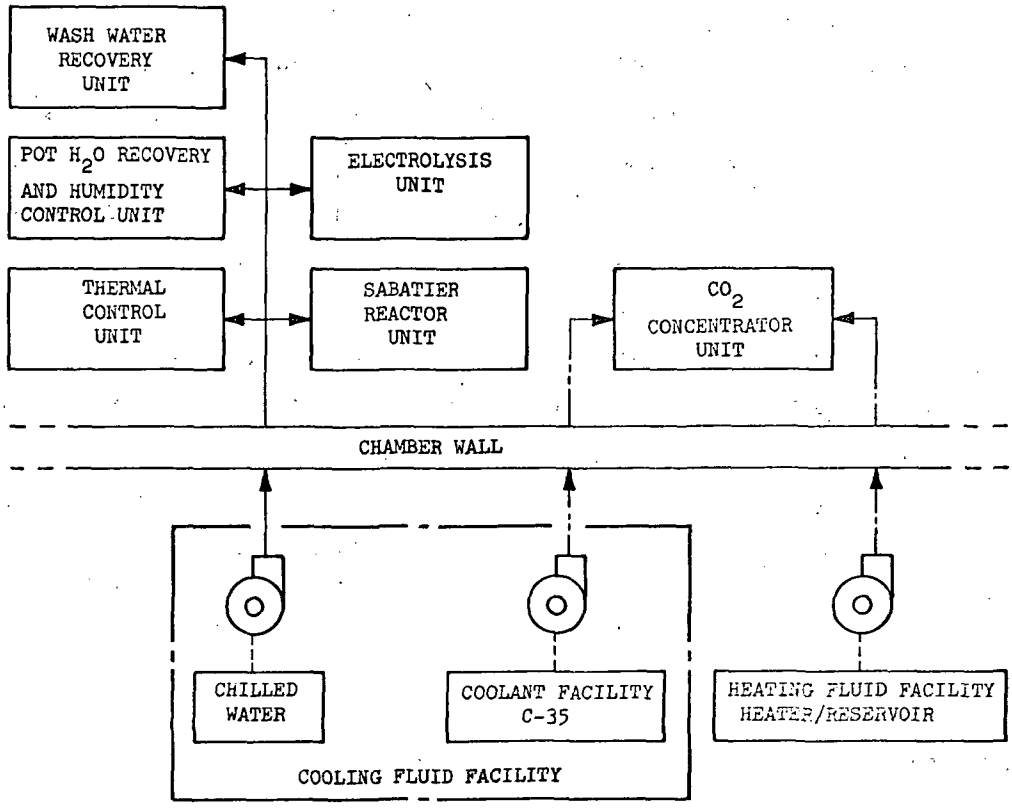


FIGURE 4-1. THERMAL SUBSYSTEM

The power distribution system for the simulator is designed to meet all industrial code requirements. As a result, a large number of circuits are provided and many of these will be lightly loaded. Further requirements were established during the safety reviews which included insurance that each circuit wire gage was adequate for the circuit breaker protection provided and that each using element was fused to prevent destructive currents. An example of the latter is the provision of individual fuses on electric motors with ratings selected to protect against locked rotor current values. Typical circuit allocations and power measurement points are shown in Reference 2, Section 4.4, Table 4-1 and Figure 4-5.

Backup power supplies must be provided in parallel with the primary 28-vdc and the 400-Hz motor generator to allow fast manual switchover if necessitated by loss of the primary supply or need for preventive maintenance.

An emergency backup 28-vdc supply must be provided to automatically activate should the facility 115 vac, 60 Hz power fail. The emergency power supply is to consist of a battery pack which, when activated, provides power to the emergency power bus for emergency onboard lighting and control of all safety-oriented chamber control functions. The emergency battery pack is maintained at full voltage with a trickle charger when not on line.

The electrical power distribution system is to incorporate relay isolation of all electrical power entering the chamber with the exception of intercom, television camera power and emergency lighting circuits which are classified as essential for safety of the crew. The electrical isolation circuits are integrated into the automatic abort sequence.

4.5 COMMUNICATIONS

A facility communications system is required to provide visual and auditory links between operating staff and crew members for:

1. Monitoring the health and well-being of the crew at all times.
2. Transmission of audio-visual repair and maintenance information to the crewmen.
3. Provision of information for evaluation of man-machine interactions during manned tests.
4. Provision of audio-video entertainment to crewmen.
5. Recording of video and/or audio information from selected areas within the test chamber.
6. Recording of video and audio information during emergency situations.
7. Control of all communications from one central console.
8. Outside telephone communication from normal intercom stations.
9. Private channels of communication from selected intercom stations.

A typical communications system layout is described in Reference 2, Section 4.5.

4.6 SIMULATOR FACILITIES OPERATING MANUAL

A Facilities Operating Manual will be prepared as a prime test document, released and maintained under standard drawing control procedures. This manual is to provide an in-depth detailed description, operating instructions, maintenance instructions, and test procedures for the facility and supporting equipment. The current release of the Facilities Operating Manual will be in the Test Control Area during manned testing.

Section 5

LIFE SUPPORT

This section contains the detail data and descriptions of the recommended Life Support System (LSS) for extended manned testing.

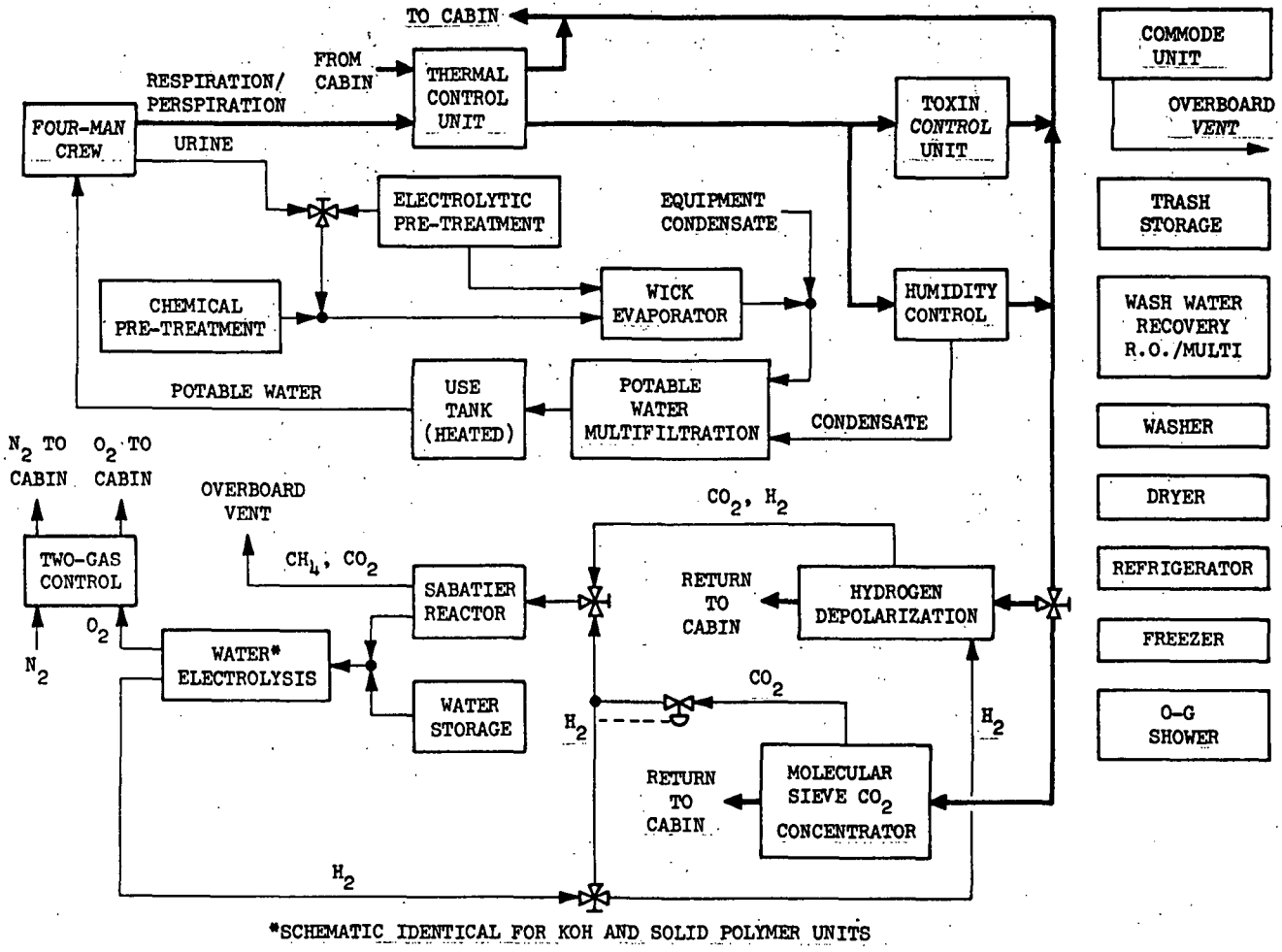
The LSS described in this section consists of baseline LSS units augmented by advanced subsystem units. A block diagram showing the LSS units integrated operation is shown in Figure 5-1. Detail unit operating schematics and photographs are shown consistent with the best information available. The schematics and photographs will be updated when the final configuration is defined.

The advanced subsystem units descriptions are based on the best information presently available. Additional information is to be incorporated when available. The advanced subsystems will be utilized to provide the prime mode of operation with the parallel baseline unit held in a standby backup mode.

The LSS functional description below is system oriented in its content. The LSS Operating Manual described in Section 5.5 will contain more detailed data in the area of unit and component description and operational criteria. Instrumentation and data management for the LSS are described in Section 11.

5.1 WASTE MANAGEMENT SUBSYSTEM

The Waste Management Subsystem consists of the baseline commode unit and advanced subsystem urine collector unit.



*SCHEMATIC IDENTICAL FOR KOH AND SOLID POLYMER UNITS

FIGURE 5-1. LIFE SUPPORT SYSTEM BLOCK DIAGRAM

5.1.1 Commode Unit

This GFE supplied unit is designed for feces collection, storage and waste tissue storage under zero-g conditions. Also included is the ability to remove individual samples for storage and/or analysis and to recharge the unit by replacing the interior bag container, slinger impeller and motor while maintaining required hygienic conditions.

Technical Description

Figure 5-2 is an operational schematic of the waste management subsystem. Figure 5-3 is a photograph showing the commode unit installed in the 90-day run configuration with pertinent operating features labeled, consistent with this description. The new installation will be similar.

The unit consists of a two-piece container assembly containing a liner, slinger motor, and bacterial filter, and a support system of seat, seat valve, control valves, blower and sampling and disinfecting assemblies.

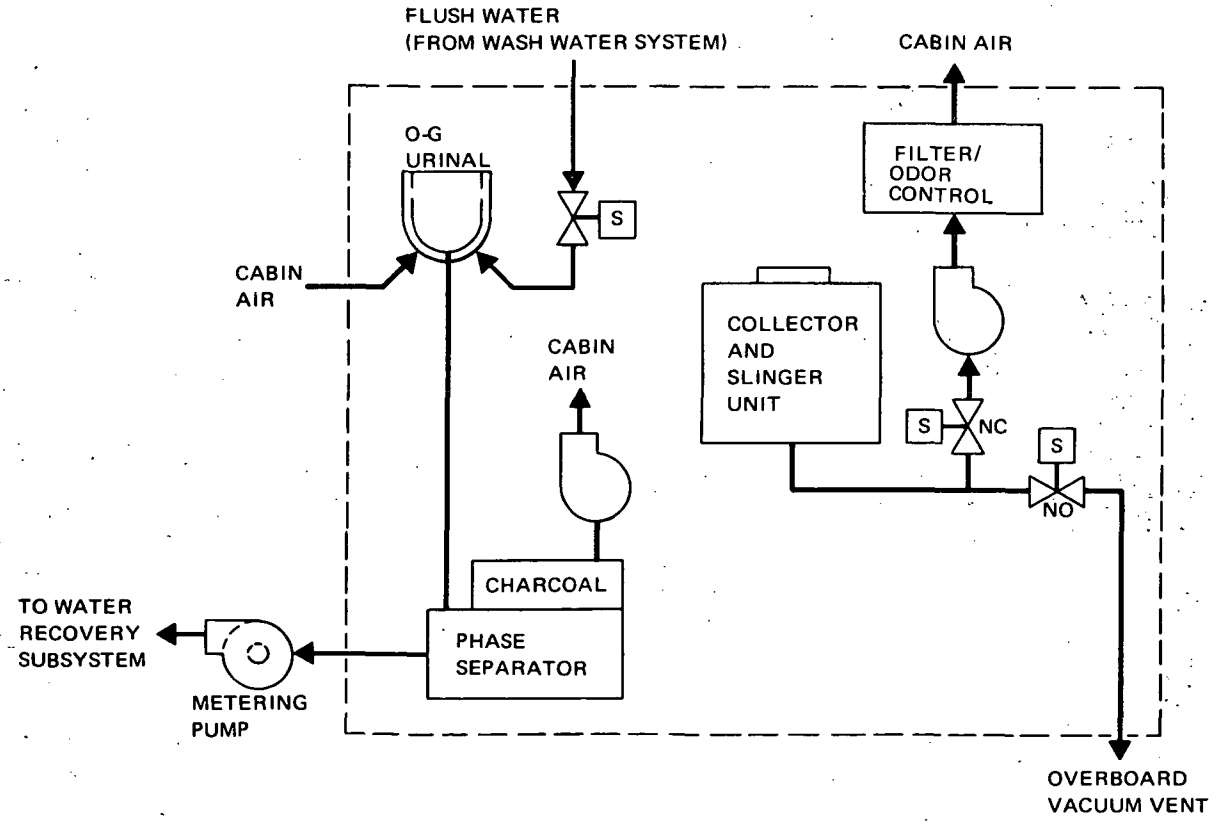


FIGURE 5-2. WASTE MANAGEMENT SUBSYSTEM

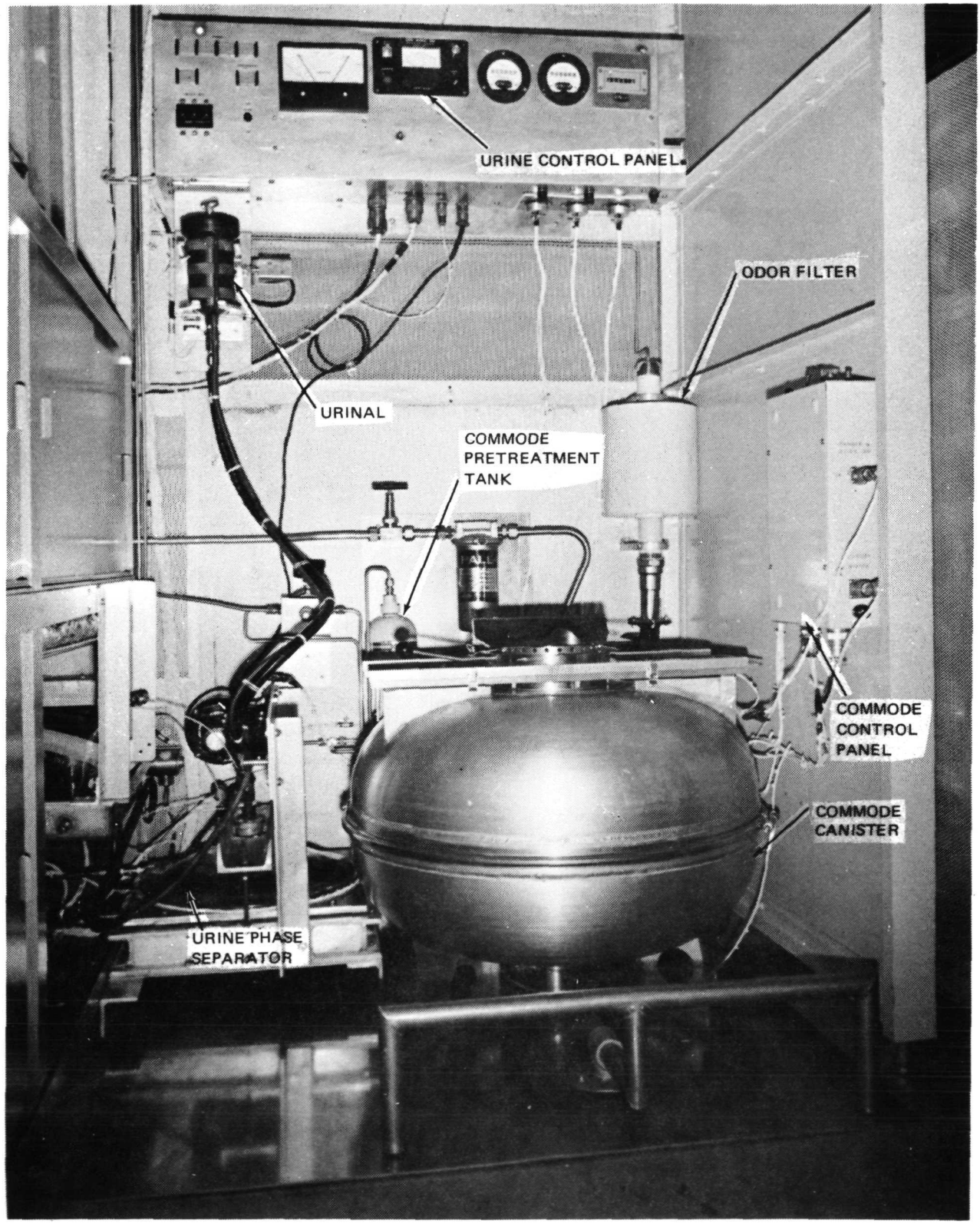


FIGURE 5-3. WASTE MANAGEMENT SUBSYSTEM (90-DAY TEST CONFIGURATION)

An air flow which is directed across the user's buttocks carries the stool into a rotating impeller. The stool is shredded and spread uniformly along the bag container wall. This achieves dense packing of the feces and allows quick vacuum drying of the resulting thin layer of moist feces.

Unit Operation

The unit is provided with an on-off operating switch, a manually operated vacuum-sealing seat valve, and indicator lights showing proper operating mode. During use, a blower circulates air which is drawn into the seat opening, entraining the bolus and carrying it into the slinger and discharging back to the cabin through a bacterial and odor control filter. After use, two solenoid valves are sequenced and the seat valve is closed to apply vacuum for dehydration of the feces. The blower and slinger motors are turned off. An injector and supply of disinfectant (Wescodyne) is provided to treat the fecal material after each use.

Individual fecal samples may be obtained by a probe sample which may be used when desired, removed, and stored for later analyses.

Maintenance

The design capacity of the commode unit will be expended and the replacement of the bag assembly, impeller and motor will be required at least once during the test. This operation will be performed by the crew with onboard stored parts and tools. The replacement bag assembly with dried feces, impeller and motor will be stored in the sealed storage container provided. In addition the disinfectant tank will require filling during the test.

The detailed procedures for the disassembly, assembly and checkout are to be described in the LSS Manual (see Section 5.5).

Operational Parameters

Input: 28 vdc
120/208 vac, 3 phase, 400 Hz
Gaseous Nitrogen

Unit Backup Description

Backup for this unit is provided through onboard stored parts and repair procedures. In the event of component failure, repair procedures will be implemented immediately.

5.1.2 Urine Collector Unit (Advanced Subsystem)

The GFE supplied unit provides for urination and transfer to the water recovery subsystem of urine under zero-g conditions.

Technical Description

The urine collector unit consists of a zero-g urinal, phase-separator, blower, and controls. The urinal is located adjacent to the commode unit and may be used separately or in conjunction with the commode. The operational schematic shown in Figure 5-2.

Unit Operation

For use, the subject begins the control cycle, starting the air blower, which brings a 0.95 liters/sec (2 cfm) air flow through the urinal and phase-separator, and starts the phase-separator motor turning at 180-260 rpm.

As urination proceeds, the urine is carried by the airstream into the phase-separator where centrifugal force from the rotor holds the urine against the outer circumference while the rotor core demists the airstream.

When urination is completed, the crewman actuates the flush water solenoid valve which allows 50 mℓ of flush water to enter the urinal and flow into the phase-separator. After the flush water solenoid valve closes, the separator transfers the urine and flush water into the water recovery subsystem.

After a predetermined time cycle, the phase-separator motor stops and the cycle is finished.

Maintenance

The maintenance required will consist of additional cleaning by periodically flushing the system with clean water.

Operational Parameters

Input: 28 vdc

H_2O (urinal rinse)

Unit Backup Description

Backup for this unit is provided through onboard stored parts and repair procedures. In the event of a component failure the urinal may still be used as a 1-G unit. Repairs will be made consistent with the crews operational priority list.

5.2 WATER MANAGEMENT SUBSYSTEM

This subsystem consists of the Wick Evaporator Unit, Electrolytic Pretreatment Unit, the Wash Water Recovery Units and Zero-g shower.

5.2.1 Wick Evaporator Unit

This unit utilizes closed-cycle air evaporation and multifiltration for the recovery of potable water from urine, crew perspiration and respiration. Unit operation requires the potability certification of the recovered water, as defined in Section 6.2.3, before crew consumption.

Technical Description

The schematic operation of this unit is shown in Figure 5-4. The basic components of this unit are: zero-g water tanks (four use tanks and two storage tanks), blower, wick evaporator, condenser/separator and multi-filtration module.

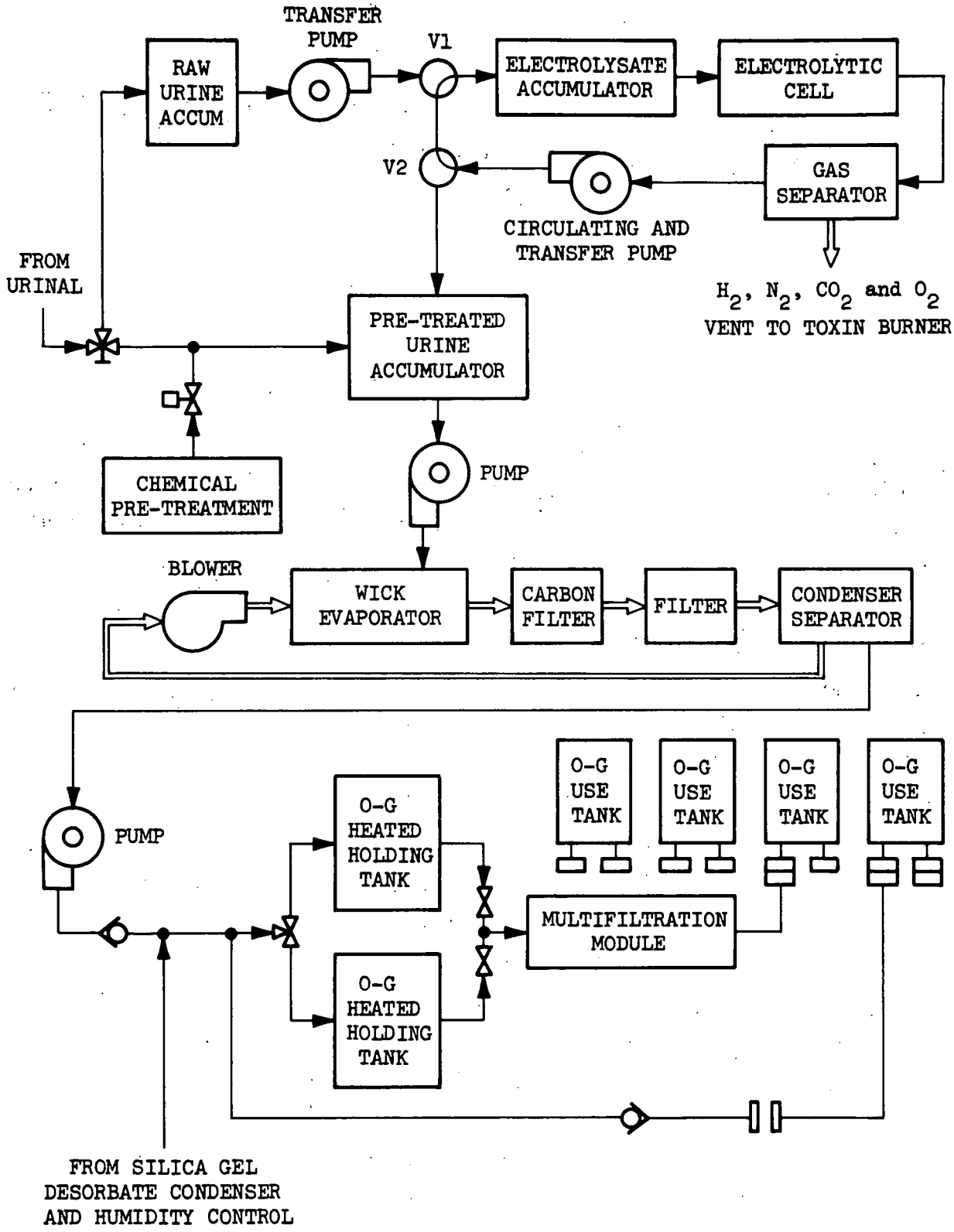


FIGURE 5-4 POTABLE WATER RECOVERY UNITS

Unit Operation

As shown in Figure 5-4, the potable water reclaimed from urine in the unit is pumped to one of the heated zero-g use tanks. Water recovered in this unit is stored in the heated storage tanks then treated in the multifiltration section, and transferred to one of the zero-g use tanks which is also heated to 344°K (160°F) to provide bacterial control. The heater water in the on-line use tank is continuously cycled in the distribution lines to the water dispenser.

When recovering water from urine, recirculating air is heated, and directed into one of the wick modules. Pretreated urine is fed to the wick where the water vapor is picked up by the heated air and the urine solids remain in the wick. The humidified air is then processed in the condenser/separator where the condensate is removed and pumped into one of two heated storage tanks.

After a minimum of 6 hours, the water is pumped from the heated storage tank through the multifiltration module to a heated use tank. Each processed use tank is certified for potability, as defined in Section 6.2.3, before crew consumption. If a tank does not pass certification, it will be pumped back through the multifiltration cycle and the certification procedure repeated. The on-line certified tanks contain enough water to support the crew until recertification is completed.

During operation the crew selects the use tank for consumption and the storage tank for transfer by sequencing applicable valves and the position of the quick disconnect lines (see LSS Manual for detail). Normal operation will require taking and processing of samples and reselecting a wick module when the one on-line module reaches its capacity. This will require the crew to reposition the wick module valve handles. The need for selecting a new wick module will be indicated by flooding of the on-line wick, evidenced by crew observance through the wick view windows.

Maintenance

Except for the transfer of water from holding to use tanks as noted above, there is no scheduled maintenance required for this unit.

Operational Requirements

Input: 208 vac, 3-phase, 400 Hz
115 vac, 60 Hz
Cooling Fluid

Output: Potable Water

Unit Backup Description

For water recovery, backup is provided by onboard stored water. In the event of failure of components of the unit providing for recovery of water from urine the initiated action will be to repair the unit using the onboard stored spare parts. The test Conductor will determine by the extent of the repair and the amount of available water in the use tanks if the backup water should be used.

5.2.2 Electrolytic Pretreatment Unit (Advanced Subsystem)

This unit produces semipurified urine that contains primarily inorganic salts.

Technical Description

This unit processes urine to remove the dissolved organic materials which are converted to H_2, N_2, CO_2 and O_2 through a series of electrochemical reactions. The trace gases are removed in the gas separator and the semi-purified urine is delivered to the wick evaporator unit.

A schematic of this unit is shown in Figure 5-4. The basic components of this unit are the raw urine accumulator, circulating and transfer pumps, electrolysate accumulator, electrolytic cell, gas separator, and selector valves.

Unit Operation

Raw urine is processed in 4-liter batches in the elctrolytic loop and on completion is transferred to the pretreated urine accumulator for processing by the wick evaporator as shown in Figure 5-4. When a batch of raw urine is available in the raw urine accumulator and the electrolytic loop has completed a previous batch, valve V-1 moves to admit raw urine to the electrolytic loop. The pump transfers the raw urine into the electrolysate accumulator until the raw urine accumulator is empty. Valve V-1 then moves to the position for circulating in the electrolytic loop.

When the electrolytic loops complete a batch (as determined by a preset timer) and the wick evaporator has processed the previous batch, valve V-2 moves to admit the semiprocessed urine from the electrolytic loop into the pretreatment accumulator. The electrolytic loop pump transfers the semi-processed urine into the pretreatment accumulator until the electrolysate accumulator is emptied. Valve V-2 then returns to the normal position for electrolytic loop processing of the next batch of raw urine.

Maintenance

There is no scheduled maintenance required for this unit.

Operating Requirements

Input: Raw Urine
115 vac, 60 Hz
28 vdc

Output: Semipurified Urine
Trace Gases (H_2, N_2, CO_2, and O_2)

Unit Backup Description

Backup for this unit is provided by chemical pretreatment (H_2SO_4, CrO_3 and $CuSO_4$).

5.2.3 Multifiltration Wash Water Recovery Unit

This unit utilizes multifiltration and heat sterilization to recovery water used for personal hygiene, laundry, and miscellaneous housecleaning chores. This unit operates in conjunction with and provides backup for the advanced subsystem reverse osmosis wash water recovery unit (5.2.4).

Technical Description

A schematic of this unit's operation is shown in Figure 5-5. A description of the unit and its maintenance and operational requirements is given in Reference 2, Section 5.1.2.3.

5.2.4 Reverse Osmosis Wash Water Recovery Unit (Advance Subsystem)

This unit utilizes reverse osmosis and heat sterilization to recover water used for personal hygiene, laundry, and miscellaneous housecleaning chores.

As noted in Section 5.2.3 this unit provides the prime function of wash water recovery and is installed in parallel with the baseline unit as shown in Figure 5-5.

Additional material describing this unit, its operational and maintenance requirements, is to be inserted here when available from the subsystem supplier when he is selected.

Unit Backup Description

Backup for this unit is provided by the baseline multifiltration unit (see Section 5.2.3). In the event of failure, the initial approach will be for the crew to repair and place the unit back in operation using the onboard stored spare parts. If the failure mode/time relationship requires activation of the backup unit, the decision will be made through the test conductor.

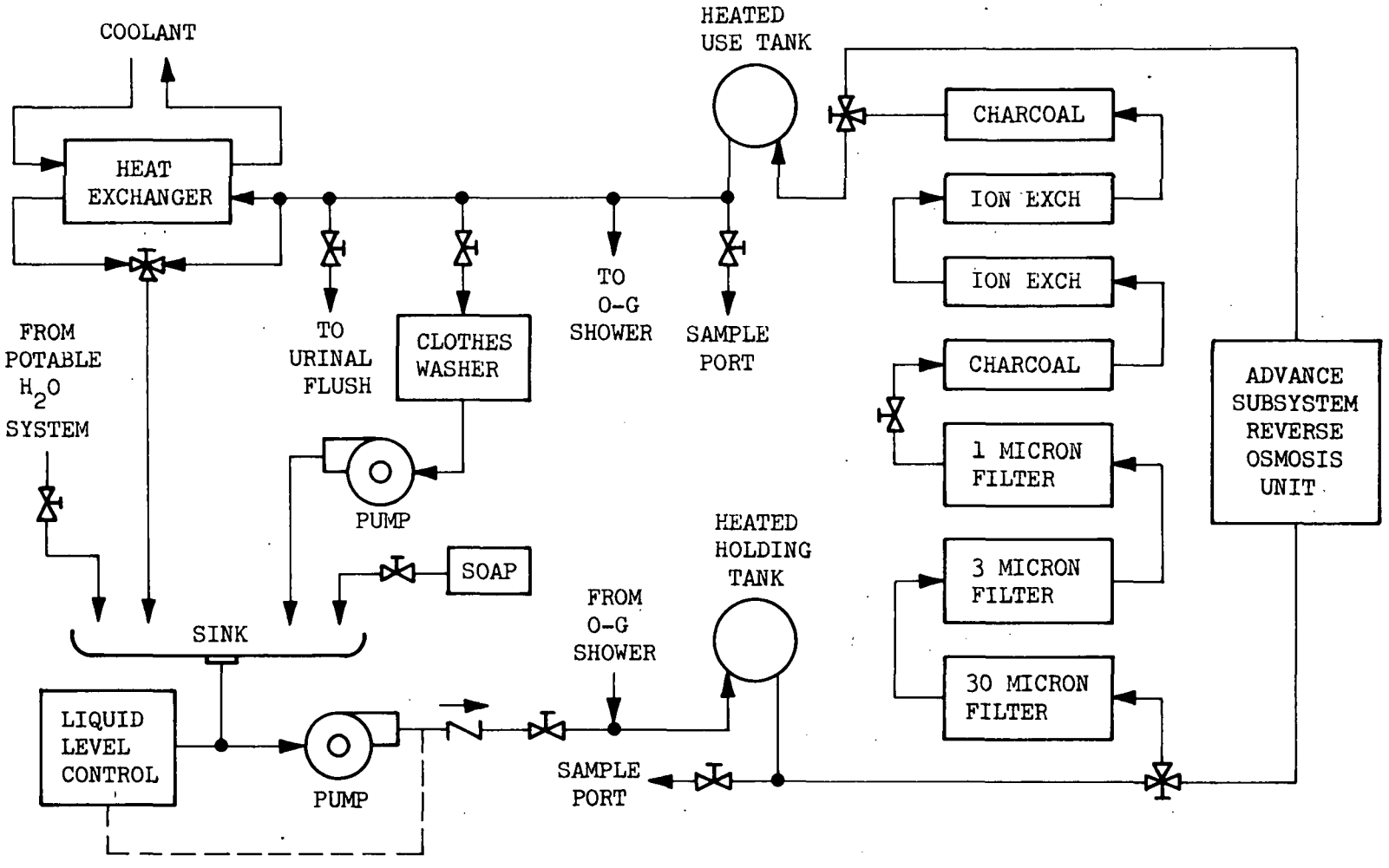


FIGURE 5-5 WASH WATER RECOVERY UNITS

5.2.5 Zero-G Shower (Advanced Subsystem)

This unit is designed to satisfy the whole body bathing requirements under zero-g conditions.

Technical Description

A schematic of this unit is shown in Figure 5-6. Basic components are: blower, air heater, hand-held nozzle, vacuum water collector, two vortex liquid/gas separators, vacuum pump and two water pumps.

Unit Operation

Heated fresh water is provided to the hand-held nozzle from the wash water recovery unit. The crewman utilizes the hand-held nozzle to wash and rinse his entire body. The nozzle has a water on-off valve which is controlled by the thumb which minimizes water usage. The blower circulates 200 cfm of heated air through the shower stall, with 10 cfm bleed for CO_2 control. The waste water is removed from the airstream by the large liquid/gas separator and transferred to the wash water recovery unit.

Residual water, which collects on the shower stall surfaces, is removed by utilizing the hand-held vacuum water scraper. The water and air are removed from the stall by a vacuum pump and the airstream is dehumidified by the smaller liquid/gas separator. The removed water is transferred to the wash water recovery unit for reclamation.

Unit Backup Description

Backup for this unit will be manual sponge bathing.

5.3 ATMOSPHERE CONTROL AND PURIFICATION SUBSYSTEM

This subsystem consists of the Thermal Control Unit, Toxin Control Unit, Molecular Sieve Carbon Dioxide Concentrator Unit, and Hydrogen Depolarized Cell.

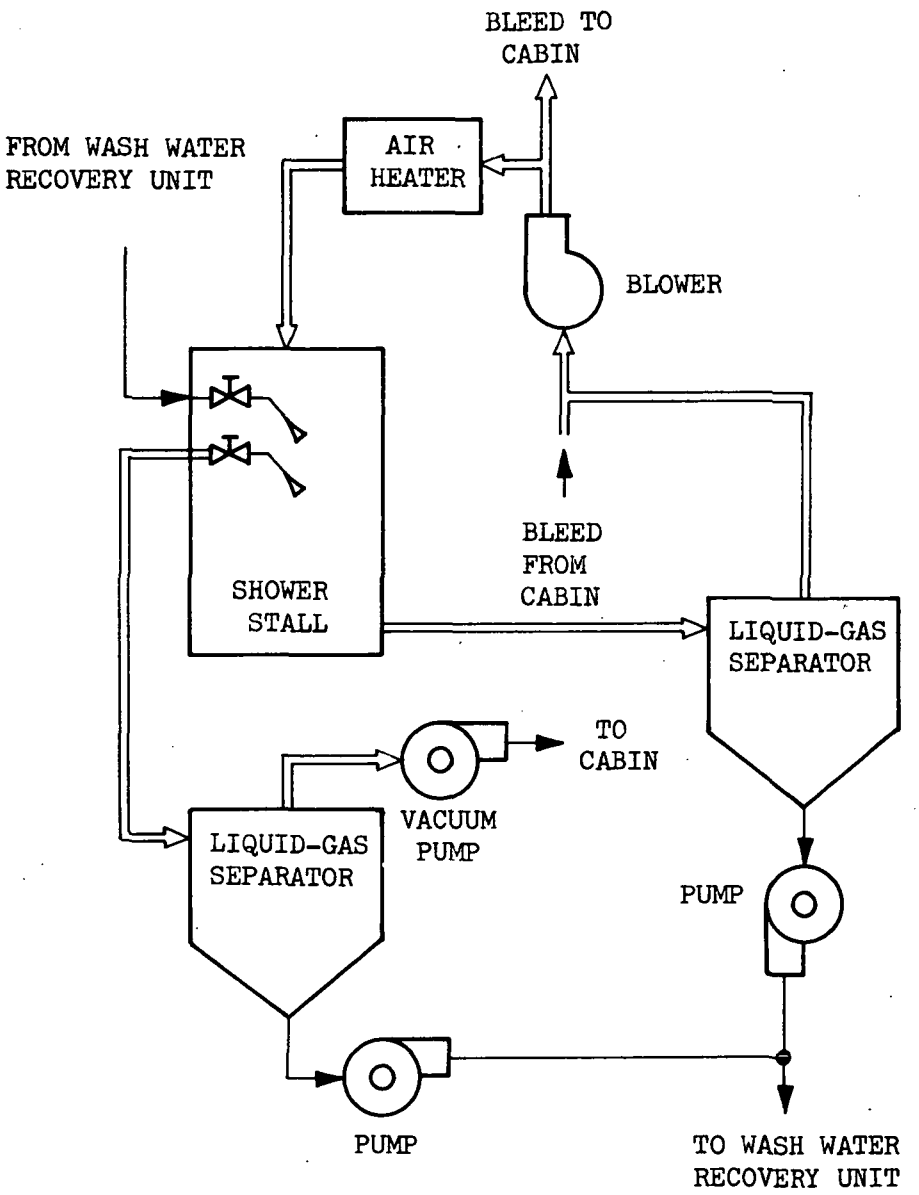


FIGURE 5-6 ZERO-G SHOWER

5.3.1 Thermal and Humidity Control Unit

This unit, supported by the facility thermal conditioning system, provides automatic temperature control of 294 ± 2.8°K (70° ± 5°F) and humidity control of 40 to 70 percent within the test chamber. The unit is designed to reject the entire sensible and latent heat load generated within the simulator.

Technical Description

A schematic of this unit's operation is shown in Figure 5-7. The unit consists of filters, supply and discharge acoustical traps, twin blowers, extended surface heat exchanger, perforated supply diffusers, zero-g condenser/separator, and electronic controls.

Unit Operation

During operation cabin air from the living area is returned to the equipment area through special sound traps located within the bulkhead. The air is then drawn into the inlet duct with two parallel blowers. This inlet flow is ducted from sensible heat load areas within the equipment area to facilitate heat removal at the source of generation. The air is filtered and passed across a counterflow heat exchanger before being discharged through perforated ceiling diffusers. Cabin temperature is controlled by a thermostat located within the living area which supplies a signal to electronic controls operating a liquid supply modulation valve to modulate the coolant temperature.

Humidity is removed from the atmosphere by diverting approximately 35.4 liters/sec (75 CFM) of the blower discharge into the humidity control condenser/separator. The condensate is delivered to the water management subsystem. Humidity control is provided by a modulating valve on the condenser/separator air discharge.

5.3.2 Toxin Control Unit

This unit provides toxin control within the test chamber by oxidizing odors and trace gas contaminants to carbon dioxide and water vapor. The unit used during the 90-day test is described in Reference 2, Section 5.1.3.2. That used in the extended manned test will be similar.

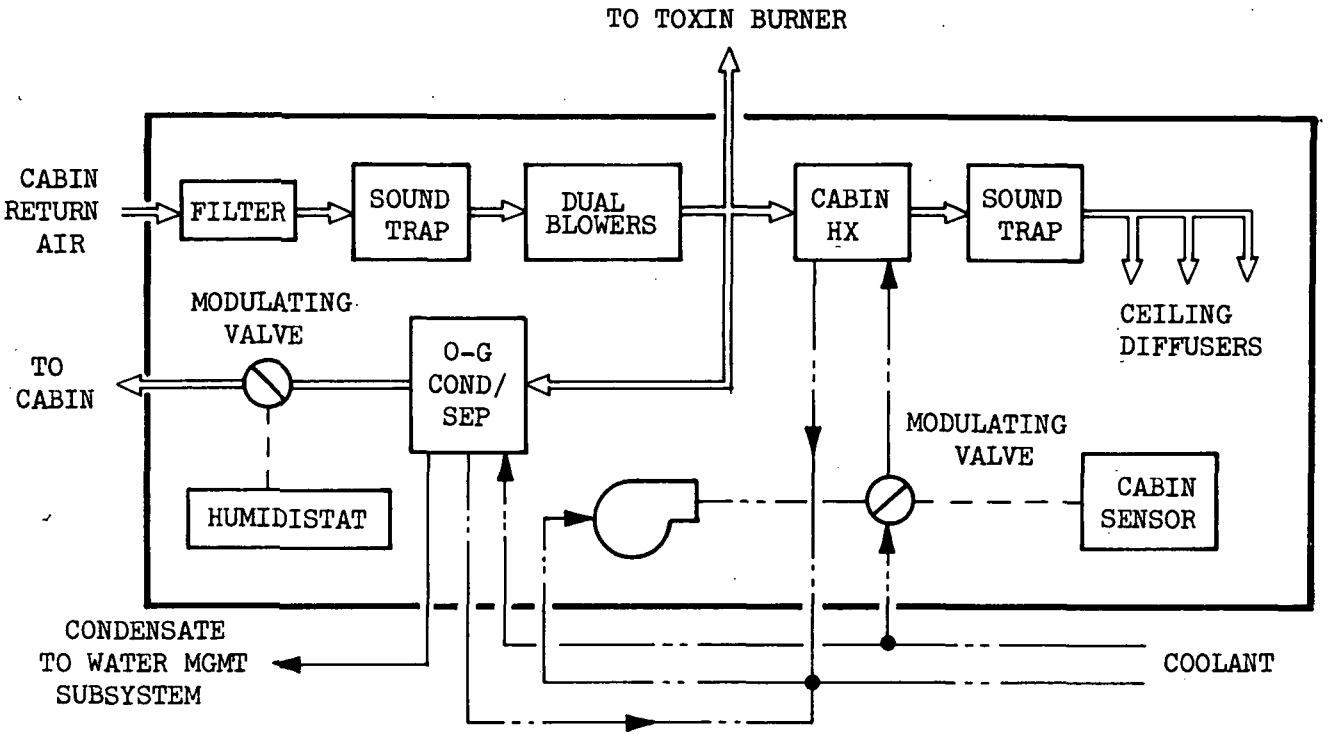


FIGURE 5-7 THERMAL AND HUMIDITY CONTROL UNIT SCHEMATIC

5.3.3 Molecular Sieve Carbon Dioxide Concentrator Unit

The Molecular Sieve Carbon Dioxide Concentrator Unit operates to maintain partial CO_2 pressure between 400 and 500 N/m^2 (3 to 3.8 mm Hg). During manned testing this baseline unit will be maintained in a backup standby mode to support the advanced subsystem hydrogen depolarized cell (Section 5.3.4) as required. Operation of the Molecular Sieve Carbon Dioxide Concentrator is described in Reference 2, Section 5.1.3.3.

5.3.4 Hydrogen Depolarized Cell (Advanced Subsystem)

The function of this unit is to maintain the partial CO_2 pressure at less than 400 N/m^2 (3 mm Hg) with a contingency level of 1,066 N/m^2 (8 mm Hg) during manned tests. This unit is to be utilized in the prime operating mode with the baseline CO_2 concentrator unit (Section 5.3.3) providing a backup function.

Technical Description

A schematic of this unit is shown in Figure 5-8. The basic components are the circulating blower, cell module, and controls.

Most cabin air containing CO_2 is fed to the cathode where the electrochemica- reaction of O_2 and water forms hydroxyl ions (OH^-). These ions react with the CO_2 forming carbonate ions ($CO_3^=$). The output is moist air reduced in partial pressure of CO_2.

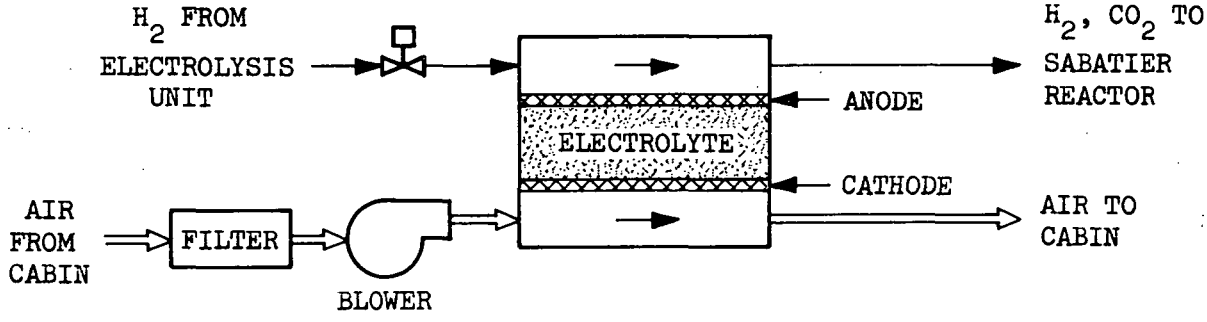


FIGURE 5-8 HYDROGEN DEPOLARIZED CELL

On the anode side, hydrogen is fed in and the electrochemical reaction of H_2 and OH^- forms water. The decrease in the concentration of OH^- in the electrolyte results in a shift in the equilibrium such that CO_2 is given off to the H_2 compartment. The resulting effluent contains the CO_2 pre-mixed with the H_2 for delivery to the Sabatier reactor.

Unit Backup Description

Backup for this unit is provided by the baseline CO_2 concentrator unit (see Section 5.3.3). In the event of failure, the initial action shall be to repair the unit using onboard spare parts. If the time to repair is such that the SSS partial pressure reaches the contingency test level (Section 6.2.2) the backup unit will be activated.

5.4 ATMOSPHERE SUPPLY AND PRESSURIZATION SUBSYSTEM

This subsystem consists of the Sabatier Reactor Unit, Electrolysis Units, and the Flight Weight Two-Gas Control Unit.

5.4.1 Sabatier Reactor Unit

The Sabatier Reactor Unit functions to chemically reduce the carbon dioxide from the CO_2 concentration subsystem and hydrogen (H_2) from the Electrolysis Unit to water and methane. The water is routed to the Electrolysis Unit (Section 5.4.2) and the methane and other noncondensable exhaust gases are vented from the test chamber and may be used as propellants in a simulated attitude control system. The Sabatier Reactor unit will be similar to that described in Reference 2, Section 5.1.4.1.

5.4.2 Static Vapor Feed Water Electrolysis Unit

This unit functions to electrolyze water from the Sabatier Reactor and makeup tank into oxygen and hydrogen. The oxygen is routed to the Two-Gas Control Unit (Section 5.4.4) and hydrogen is routed to the Sabatier Reactor (Section 5.4.1) or the Hydrogen Depolarized Cell (Section 5.3.4).

During manned testing this baseline unit will be maintained in a backup mode to support the advanced subsystem Solid Polymer Water Electrolysis Unit (Section 5.4.3) as required.

Technical Description

The water electrolysis unit is a nonflight system which incorporates the basic principles and fundamentals of a zero-g flight-type unit, but not necessarily the weight, bulk, and detail design. Oxygen output capacity of the 3 operating modules of the system is up to 4.54 kg/day (10 lb/day). To meet the specified requirements of 3.63 kg/day (8 lb/day) of oxygen, the unit must produce 0.151 kg/hour (0.333 lb/hour), 0.051 kg/hour/module (0.111 lb/hour/module). This, in turn, requires 0.170 kg (0.375 lb) of water be fed to the unit each hour, and 33.9-amp total (an average of 11.3 amps applied to each module). A description of this unit is included in Reference 2, Section 5.1.4.2.

5.4.3 Solid Polymer Electrolyte Water Electrolysis Unit (Advanced Subsystem)

The function of this unit is to electrolyze water from the Sabatier reactor and makeup tank into O_2 and H_2. The oxygen is routed to the two-gas control unit (Section 5.4.4) and the hydrogen is routed to the Sabatier Reactor (Section 5.4.1) or the Hydrogen Depolarized Cell (Section 5.3.4).

This unit is to be utilized in the prime operating mode with the Baseline Static Vapor Feed Unit (Section 5.4.2) providing a backup function. Both units will be integrated in parallel within the LSS so that operation of either unit will maintain the regenerative operating integrity of the overall LSS. However, due to space limitations, the Solid Polymer Unit may be installed outside of the test chamber.

Technical Description

A schematic of this unit is shown in Figure 5-9. The electrolysis cells are constructed with solid plastic sheets (ion exchange membrane) of sulfonated perfluoro linear polymer as the sole electrolyte material. Water is supplied to the oxygen evolution electrode (anode) where it is electrochemically decomposed to provide oxygen, hydrogen ions, and electrons. The hydrogen ions move to the hydrogen evolving electrode (cathode) by migrating through the ion exchange membrane. The electrons pass through the external circuit to reach the cathode and the hydrogen ions and electrons recombine to produce hydrogen gas.

Unit Backup Description

Backup for this unit is provided by the Baseline Static Vapor Feed Electrolysis Unit (see Section 5.4.2). In the event of failure, the initial action shall be to repair the unit using onboard spare parts. If the time to repair is such that the required O_2 and/or H_2 pressure cannot be maintained, the backup unit will be activated.

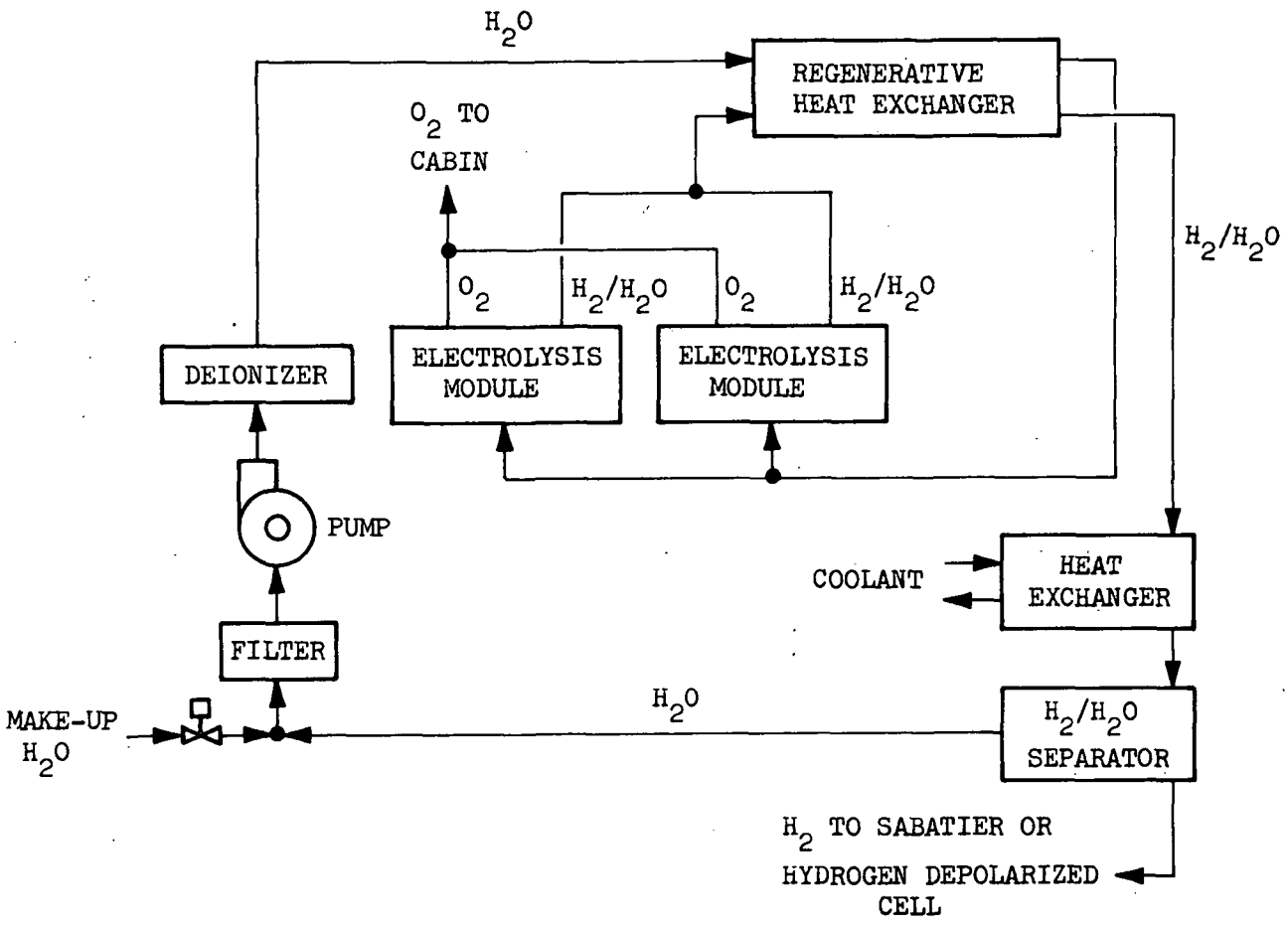


FIGURE 5-9 SOLID POLYMER ELECTROLYTE WATER ELECTROLYSIS UNIT

5.4.4 Flight Weight Two-Gas Control Unit

This unit functions to monitor and maintain the required atmospheric partial oxygen and nitrogen pressure by electronic pulse modulating controls. The operation of the two-gas control and associated mass spectrometer sensor are described in Reference [2], Section 5.1.4.4.

5.5 LSS Operating and Checkout Manual

A LSS Operating and Checkout Manual must be prepared by the test contractor. This manual is a prime test document, released and maintained under standard drawing control procedures. The manual provides an in-depth detailed description, operating instructions, component nomenclature, calibration procedure, instrumentation details, startup and shutdown procedures of the LSS units described in Section 5. The current release of the LSS Operating Manual will be in the Test Control Area during manned testing.

Section 6

SUPPORT EQUIPMENT, FACILITIES AND PROCEDURES

The equipment, facilities, and procedures described in this section are required for support of the simulator and life support system during the extended manned test program.

6.1 EMERGENCY EQUIPMENT

Lists of emergency equipment suggested for support of extended manned testing are presented in Reference 2, Section 6.1 and Tables 6-1 and 6-2.

6.2 ENVIRONMENTAL SUPPORT LABORATORY

This laboratory must be equipped to provide the analytical information required before the start of the test, during the course of the test and after its completion. The work which will be performed can be segmented as follows:

1. Selection of materials and supplies.
2. Analysis of air for organic and inorganic trace contaminants.
3. Water analysis
4. Additional analyses

6.2.1 Selection of Materials and Supplies

~~The purpose of this plan is to establish nonmetallic materials selection and~~ acceptance guidelines and test requirements for controlling and minimizing the flammability and toxicity of the nonmetallic materials used in the test chamber and allied test and installation facilities. References 1, 3, and 4 shall be considered the governing documents relating to the performance required by this material control plan.

The detail test requirements and procedures pertinent to the accomplishment of material control are defined in Appendix F.

6.2.2 Analysis of Air for Organic and Inorganic Trace Contaminants

The composition of the atmosphere during the manned operation will be determined both on a continuous basis and by individual samples taken at frequent intervals. Continuous analysis is performed by the Gas Analysis Console, which includes LIRA infrared analyzers for carbon monoxide and carbon dioxide and flame ionization measurement of total hydrocarbons.

Representative samples of cabin air, taken from any one of a number of pre-selected locations are pumped to a Gas Analysis Console and can be withdrawn by syringe and needle technique for detail analysis by gas chromatograph or measured quantities can be passed through a liquid nitrogen freeze-out trap for concentration of organic trace contaminants.

Identification of gas chromatographic peaks produced by the flame ionization detector will be based on calibrated elution times which have been carried out with 75 compounds. Table 6-3, Reference 2, is a minimum list of the components for which these calibrations must be maintained.

More definitive identification must be made by mass spectrometry and by infrared spectrophotometry, for which larger volume air samples are required. It was noted in all past analyses of the cabin air that the same chromatographic peaks appeared during the entire operation. Once the identity of these peaks has been determined and confirmed, only the daily fluctuations of the contaminant levels need be determined.

Inorganic compounds which cannot be determined by flame ionization will be analyzed by conventional wet-chemical procedures. Table 6-1 indicates the types of contaminants tested for and the methods to be employed. Also included is the test termination level for these contaminants. For procedures involving trace contaminants test termination, see Section 3.6.4.

The test termination levels specified in Table 6-1 are in accordance with those recommended by the ad hoc committee on Air Quality Standards to the NAS-NRC Space Science Board where indicated (Reference 5). These levels are based on a pressure of one atmosphere.

Table 6-1.

MAJOR ATMOSPHERIC CONTAMINANTS IN SPACE STATION SIMULATOR

Contaminant	Method of Analysis	Accuracy	Normal Operations	Lower End of* Contingency Operations	Abort Level*	Allowable Level Specified By Committee
CO (ppm)	MSA, Lira Infrared Anal.	±2.0	12.0	70	150	X
CO_2 (mm Hg)	MSA, Lira Infrared Anal.	±0.4	3.0	8	**	
Hydrocarbons (ppm)	Beckman Flame Ionization Anal.	±2.0	4.0	40	200	
NH_3 (ppm)	Nessierization	±1.0	4.0	50	100	
Aldehydes (ppm)	Absorption in Bisulfite S n.	±0.005	1.0	10	20	
SO_2 (ppm)	Sod. Tetrachloromercurate-p-rosaniline	±0.25	0.5	5	8	
H_2S (ppm)	Cd. Sulfate-amine Sulfuric Acid	±1.0	1.0	10	20	
$((NO)_x$ (ppm $NO_2))$	Salzman Reaction	±0.1	0.5	1.0	10	
O_3 (ppm)	RTI Ozone Detector	±0.001	0.03	0.1	1.0	
Chlorine (ppm)	O-Tolidine Reaction	±0.04	0.1	0.5	1.0	
Cyanides (ppm)	Palladium Chelate Reaction	±1.0	1.0	2.0	10	
Phosgene (ppm)	Test Paper Treated with Indicator	±0.2	0.05	0.10	1.0	
Ethanol (ppm)	Gas Chroma., Flame Ionization	±0.2	2.5	200	1000	
Toluene (ppm)	Gas Chroma., Flame Ionization	±0.2	0.5	20	200	
2-Ethyl Butanol (ppm)	Gas Chroma., Flame Ionization	±0.2	1.0	15	40	
n-Butanol	Gas Chroma., Flame Ionization	±0.2	1.0	10	100	X
2-Butanone	Gas Chroma., Flame Ionization	±0.2	2.0	20	200	X
Chloroform	Gas Chroma., Flame Ionization	±0.2	0.5	5	50	X
Dichloromethane	Gas Chroma., Flame Ionization	±0.2	2.5	25	500	X
Dioxane	Gas Chroma., Flame Ionization	±0.2	1.0	10	100	X
Ethylacetate	Gas Chroma., Flame Ionization	±0.2	4.0	40	400	X
2-Methylbutanone	Gas Chroma., Flame Ionization	±0.2	2.0	20	200	X
Trichloroethylene	Gas Chroma., Flame Ionization	±0.2	1.0	10	100	X
1,1,2-Trichloro; 1,2,2-Trifluoroethlane and related congeners	Gas Chroma., Flame Ionization	±0.2	20.0	100	1000	X
Formaldehyde	Not Available	-	0.05	0.10	2.0	X
Dichlorolacetylene	Not Available	-	0	Detected	0.1	X
Vinylidene Chloride	Not Available	-	2.0	10	25	X

*For procedures involving test contingency and test termination, see Section 3.2.
**>60 (3 min), 60 to 40 (10 min), 40 to 30 (30 min), 30 to 20 (60 min), 20 to 15 (48 hours).
+For sea level operating pressure.

The number of air samples withdrawn from the test chamber will depend on the results of analyses as they are conducted during the test. Initially, daily samples should be run for almost all contaminants listed in Table 6-1. If higher than normal contaminant concentrations are observed, additional test runs will be required. When an acceptable analytical pattern emerges, the frequency of sampling may be reduced. Table 6-2 shows the planned frequency of analysis to be used initially in the test and the gas volumes to be required for these analyses. Most of the residual gas will be returned to the chamber, as indicated. It is estimated that gas analysis will result in the loss of 20.7 liters of cabin atmosphere per week.

6.2.3 Water Analysis

Analysis of water samples will be conducted in the on-board laboratory. The equipment required for the chemical analysis is shown in Table 6-3. The equipment required for microbiological analysis of the water is described in Section 6.3. These analyses will be conducted on potable water to demonstrate compliance with the standards established by the NAS/NRC ad hoc committee (Reference 6). Additional analyses will be performed on samples taken from the Wash Water Recovery Units, from stored water to be used for electrolysis, and from water recovered from the Sabatier Reactor Unit.

Table 6-2

SAMPLE FREQUENCY AND VOLUME FOR ATMOSPHERIC TRACE CONTAMINANTS

Sample Sizes	Volume per Sample (liters)	Gas Volume per Week (liters)	Frequency
Total Aldehydes	120	840*	Daily
Phosgene	0.3	0.6*	Twice weekly
Hydrogen Chloride	15	30.0*	Twice weekly
Chlorine	20	40.0*	Twice weekly
Sulfur Dioxide	1	2.0	Twice weekly
Oxides of Nitrogen	1	7.0	Daily
Ammonia	1	7.0	Daily
Hydrogen Cyanide	1	2.0	Twice weekly
Hydrogen Sulfide	1	2.0	Twice weekly
Total Organics by GC	0.1	0.7	Daily
Total Organics Freeze-out by GC	20	20.0*	Weekly
Total Organics Freeze-out by Mass Spec.	20	20.0*	Weekly

*Air sample will be returned to

Table 6-3

ON-BOARD WATER ANALYSIS LABORATORY

Item	Quantity	Name	Description	Storage
1	2 Bottles	Acid, Acetic	500 mℓ/bottle	TBD
2	1	Analyzer, Infrared	Beckman Model 215A	Counter
3	1	Analyzer, Total Organic Carbon (TOC)	Beckman Model 915	Counter
4	100	Bags, Sample		TBD
5	2	Cell, Conductivity	Beckman CEL-G2	Counter
6	TBD	Chemicals, Reagent.		Unused Pass Through Port
7	1	Colorimeter	Coleman	Counter
8	3	Eyedroppers	Use with Item 1	TBD
9	1	Meter, Conductivity	VSI Model 31	Counter
10	1	Meter, pH	Coleman Model 31	Counter
11	1 Rack	Nessler Tubes	12 Tubes	Counter
12	1	Power Supply	Coleman Model 6-054; Use with Item 7	Counter
13	3	Probes	Coleman 3-410, 3-420 & 510	Counter
14	1	Recorder, Strip Chart	Beckman 10 inch; Use with Item 3	Counter
15	1 Bottle	Solution, pH Buffer	Beckman 3501	TBD
16	1	Turbidimeter	Delta Scientific Model 260	Counter

Table 6-4 lists the sample locations, tests conducted, frequency, sample size, where analysis performed and disposition of sample after analysis.

The physical properties analysis will include turbidity, color, taste, odor, foaming, pH, and specific conductivity.

The chemical properties analysis will include, but not be limited to the following (subscripts correspond to those in the table): barium$_{(2)}$, cadmium$_{(2,5)}$, chromium$_{(2,5)}$, copper $_{(2,5)}$, lead$_{(2,5)}$, silver$_{(2,5)}$, nickel$_{(5)}$, arsenic$_{(2)}$, boron$_{(2)}$, chloride$_{(2,5)}$, fluoride$_{(2)}$, nitrate and nitrite$_{(2,5)}$, selenium$_{(2)}$, sulfate$_{(2,5)}$, carbonates$_{(5)}$, total organic carbon$_{(1,2,3)}$, total dissolved solids$_{(2,3,5)}$, and iodine$_{(4)}$.

In addition to the chemical analyses noted above, conducted to the standards of Reference 6, the following analyses shall be performed for qualification of potable water for consumption. These analyses will be performed on the X_1 samples as noted in Table 6-4:

1. Measurement of chromium (Cr^{+6}) ions. The concentration of Cr^{+6} ions shall not exceed .05 ppm.

2. If the pH of the water sample from a potable storage tank exceeds 7.0, acetic acid shall be added to the tank via the recirculating loop and circulated until well mixed in order to correct the condition. After correction of the pH level to below 7.0, the concentration of ammonium salts shall be no more than 10 mg/liter. In the event this NH_3 level is exceeded the potable storage tank may be certified for consumption with NH_3 concentration of 10 to 500 mg/liter for a continuous period not to exceed 3 days.

All methods used, except those for the metal analysis, will be according to Reference 7. The metal analysis will be done by atomic adsorption. Based on these test data and in conjunction with microbiological test results, the Medical Director will decide on the potability of each water supply.

TABLE 6-4

SAMPLE ANALYSIS

Sample Location	Physical Properties	Chemical Properties	Bacteria	Frequency	Sample Size (ml)	Performed Onboard	Disposition
Potable H_2O							
Tanks Completing Fill Cycle			X	Every 2 days until usage	100	X	Return to urine accumulator
	X	X_1		Every 2 days until usage	100		
		X_2		Pre- and post-test	1000		
Potable Dispenser			X	Weekly	100	X	
Tank No. 1 or 2 Holding			X	Every 2 days	100	X	

TABLE 6-4 (Continued)

SAMPLE ANALYSIS

Sample Location	Physical Properties	Chemical Properties	Bacteria	Frequency	Sample Size (ml)	Performed Onboard	Disposition
Potable H_2O							
Multifiltration Module Outlet			X	Weekly when in use	100	X	Return to urine accumulator
		X_1			100	X	
Backup Tank		X_4		Weekly	25	X	
Miscellaneous H_2O							
Sabatier Output	X	X_5		Pre- and post-test	100		
Electrolysis Backup Tank	X	X_5		Pre- and post-test	100		

TABLE 6-4 (Continued)

SAMPLE ANALYSIS

Sample Location	Physical Properties	Chemical Properties	Bacteria	Frequency	Sample Size (ml)	Performed Onboard	Disposition
Wash H_2O							
Tank No. 7 Process			X	Weekly	100	X	Return to Sink
	X	X_3			100	X	
Tank No. 8 Use	X	X_3			100	X	
			X		100	X	
Wash Dispenser	X					X	Return to Sink

Pre- and post-test measurement of chemical oxygen demand (COD) will be made on potable water samples to maintain a correlation between TOC and COD data.

6.2.4 Additional Analyses

During the test a wide variety of additional analyses will be required. These will be performed at least once each week and will include, as a minimum, the following: Sabatier exit gas, for composition including CO_2, CH_4, O_2, N_2, H_2, CO and trace contaminants; electrolysis output, O_2 for H_2 and N_2; and H_2 for presence of N_2 and trace contaminants; CO_2 accumulator outlet, for presence of organic trace contaminants, O_2, N_2 and Freon compounds; collection and measurement of particulates; evaluation of analytical methods for formaldehyde and ozone, and comparison between existing and newly developed methods for water analyses. Additional support may also be required for special analytical procedures.

6.3 BIOMEDICINE FACILITIES AND PROCEDURES

6.3.1 Onboard Medical Laboratory

During the course of the test, the crew members will be required to conduct a number of medically related procedures. These procedures are defined in Section 9.0. All equipment necessary for these procedures will be incorporated in the simulator at the beginning of the run and will constitute the onboard medical laboratory. The equipment listed in Table 6-5 includes those items required for performing the baseline medical procedures; additional items may be required for special studies.

6.3.2 Medical Kit

A medical kit including provisions for treating illnesses and minor injuries will be included. The items in this kit will be used only under the supervision of the Medical Director. It is recommended that Table 11-2, page 254 - 256, Reference 2, should be used as a guide in selecting the items to be included in the medical kit.

Table 6-5

ON-BOARD BIOMEDICAL LAB EQUIPMENT AND SUPPLIES

Category	Item Name	Quantity	Description
Microbiology	Millipore Field Monitors	100	
	Sample Tubes	100	
	Syringe	4	
	Ampoule Media	100	
	Magnifying Glass and Counter	1	
	Incubator	1	30°C
	Incubator	1	37°C
	Refrigerator	1	277°K (4°C)
	Microbiology Safety Hood	1	
	Nasal Swabs	50	
	Throat Swabs	50	In sterile tubes
	Agar Plates	100	Contain 4-5 selected media
Hematology	Vacutainers	25	
	Hypodermic Needles	25	
	Blood Storage Tubes	25	
	Tournequets	4	
	Vacutainer Needle Holders	4	
	Slides, Glass, Microscope	50	
	Microlance Blood Lancets	20	
	Hemocytometer	1	
	Counter, Tally	1	

Table 6-5 (Continued)

Category	Item Name	Quantity	Description
Hematology	Capillary Tubes, Hematocrit	50	
	Seal-Ease Sealer	2	
	Crito Cap, Micro-Hematocrit Tube Reader	1	
	Hemoglobinometer	1	
	Centrifuge	1	Counter
	*Refrigerator	1	277°K (4°C)
	Freezer	1	253°K (-20°C)
Urine Sampling	Volumetric Cylinder, 1 Liter Graduated	1	
	Volumetric Cylinder, 250 mℓ		
	Volumetric Cylinder, 100 mℓ	1	
	Beakers, 600 mℓ	2	
	Funnel, small	1	
	Urine Storage Bags	125	
	*Refrigerator	1	277°K (4°C)
	*Freezer	1	253°K (-20°C)
Physiological Measurement	Scale	1	Body Weight
	Thermometer	2	Body Temperature
	Spirometer	1	Pulmonary Function
Miscellaneous	Band-aids	50	
	Adhesive Tape	1	3 in. roll
	Scissors	1	
	Cotton Balls	60	

* Listed in previous category.

6.4 ADDITIONAL SUPPORT EQUIPMENT AND LABORATORIES

Photographic documentary support will be required throughout the program. This support shall be used in the continual updating effort of this document (see Section 1.5). Program management shall provide controls for the formulation of a program photographic file. In addition, the Photographic Department shall provide and train the crew in the use of camera equipment to assist in documenting internal functions in the manned tests.

A company car shall be provided for the sole use of the program during the manned testing phase. This car will be used for interplant and local driving in support of the manned test program. The use of this car will be controlled by the Test Conductor on duty.

In-depth clinical and toxicological testing requires specialized equipment and a highly qualified professional staff. Both facilities and personnel must be available for special testing and consultation in these areas throughout the term of the program, providing standard clinical chemistry and hematological capability. These labs must employ modern, automated analytic equipment with proven quality control and accuracy.

The supporting laboratories will be used in the extended manned test program as needed to satisfy specific experimental test requirements.

Section 7

LOGISTICS AND SUPPLIES

Logistics planning is necessary to assure the successful completion of the manned test. It has as its objectives the identification of spares and maintenance actions necessary to permit continuous operation of the simulator subsystems. The basis of the logistics planning task is the Failure Mode, and Effects Analysis (FMEA). The results of the FMEA are used as a basis for generating the spare parts lists for the various subsystems. The spares lists must be reviewed by the responsible subsystem engineers with adjustments for commonality of spares between subsystems and for practical levels of component replacement or repair. The maintenance procedures are then formulated and the tool and storage volume requirements delineated. During the maintenance and tool-provisioning tasks, the spares lists may be further modified depending on the feasibility of the required maintenance procedures.

7.1 FAILURE MODE AND EFFECT ANALYSIS (FMEA)

The FMEA determines the qualitative effects of each failure mode of each component on the subsystem and on the mission operations. This permits the classification of each failure mode according to a safety/reliability index which in turn identifies undesirable single-point failures. The FMEA will be conducted for the following baseline units of the life support system:

1. Wash Water Recovery Unit
2. Potable Water Recovery Units
3. Commode Unit/Urine Collector
4. CO_2 Concentrator Unit
5. Sabatier Reactor/Toxin Control Units
6. Electrolysis Unit
7. Two-Gas Control Unit

8. Thermal and Humidity Control Unit
9. Thermal Conditioning System (part of facility equipment)
10. Electrical Power Systems

The FMEA will also be conducted for the advanced subsystems when adequate definition is available.

Failures must be classified in accordance with the severity of the resulting effect. Classes of failures are defined as follows:

Class	
1	Fatal to one or more crew members.
2	Immediate abort.
3	Correction required or possible test termination will result if alert levels are exceeded.
4	Alternate, backup system utilized or corrective maintenance required.
5	System performance degradation without requirement for correction.

Class 1 and 2 failures result in the generation of emergency procedures and the requirement for crew-protective devices. Class 3 and 4 failures serve as the basis for spares provisioning and requirements for redundancy. Class 5 failures result in the identification of degraded mode procedures.

7.2 SPARES SELECTION AND PROVISIONING

A spares selection program similar to that described in Section 7.2 of Reference 2 should be used to provide adequate support of the extended manned test.

7.3 ONBOARD MAINTENANCE

All maintenance that can be performed within the confines and constraints of the chamber atmosphere and which does not compromise crew health and safety will be performed onboard. Subsystems requiring periodic scheduled maintenance are identified in Section 5. Training requirements for these are defined in Section 8.

A summary of provisions for scheduled and unscheduled maintenance will be included as part of the NASA Readiness Review Data. The schedule for accomplishment of periodic maintenance actions will be integrated into the work-rest schedule. Upon the conclusion of the test, as a result of data collected therefrom, a failure and maintenance report will be provided. This shall include manpower, time requirements, and spares utilization records for all scheduled maintenance actions.

7.3.1 Procedure

Detailed procedures for maintenance actions will be provided as part of a package of documentation stored onboard the chamber. Both consultations and additional instructions may be provided from outside the chamber utilizing the communications capability of the audio-video system and onboard data link.

7.3.2 Onboard Tools

A maintenance tool kit must be provided on-board the simulator. Table 7-3 of Reference 2 presents a suggested list of maintenance tools and equipment. Additional tool requirements will be determined prior to the initiation of manned testing and will be based upon unusual maintenance requirements.

Section 8

CREW INTEGRATION

This Section describes the crew integration activities required pretest, during the test, and post-test to insure that (1) an integrated, trained, and motivated crew of capable on-board and support personnel will be available for the manned test; (2) the on-board habitability facilities for sustaining and supporting the crew are adequate; (3) meaningful, realistic, and objectively oriented activities are efficiently scheduled for performance during the manned test; and (4) performance of the on-board crew during the test is adequately evaluated. Included are subsections on Screening and Selection, Training, Scheduling, Habitability Subsystem, and Behavioral Assessment.

8.1 SCREENING AND SELECTION

8.1.1 On-Board Crew

Six crewmen (4 on-board and 2 backup) will be selected using a multistage program designed to obtain and evaluate information on the following abilities:

1. Scientific and technical skills and capabilities
2. Emotional maturity and mission motivation
3. Physical health and health prognosis
4. Prognosis for isolation tolerance
5. Crew role potential and job skill proficiency
6. Crew compatibility
7. Adaptability and conformity to mission requirements.

A pool of potential crew candidates will be established from graduate school attendees at local colleges and universities and from recent college or university graduates in the local area. General screening criteria for the selection of pool members will be as follows:

1. Graduate school level volunteers; preferably candidates for an advanced degree.

2. Demonstrated interest in physical fitness.

3. Academic interests in engineering, the physical sciences, the biological or social sciences. Interest should be demonstrated across disciplines.

4. Uninterrupted 17-week availability during the pretest (9 weeks), test (4 weeks), and post-test (4 weeks) periods.

5. Appropriate motivation including intention to pursue a technically related profession.

6. Within normal ranges on psychodiagnostic tests.

7. Evidence of mechanical aptitude and acceptable maintenance skill.

8. Evidence of interest in cooperative group efforts, as well as individual activities.

9. Psychologically willing and able to take and carry out direct orders from an authority figures.

Contacts will be established with student placement offices at each of the universities. Placement offices will be requested to contact appropriate department heads and solicit their assistance in the identification of graduate students who are qualified and interested in participating in the program. Male and female applicants will be considered. Contact will also be made with the state employment office to solicit applications from technically trained, unemployed persons in the local area.

A recruiting brochure will be prepared and provided for use by the various placement offices. It will be stressed that graduate school applicants must have written approval of their department chairmen or faculty advisors before applying.

Once an application has been received, a packet of questionnaires will be mailed to the applicant to be filled out and returned. These questionnaires include: (1) Cornell Medical Index (2 forms - men and women), (2) Biographical Survey, (3) Myers Inventory, (4) Opinion Survey, and (5) Life Crises Questionnaire (Appendix H).

Based on review of questionnaire responses and evaluation of their previous academic accomplishments, selected applicants will be invitied to come in for a personal interview. Discussions during the interview will resolve about ascertaining the availability of the applicant for the entire study period and will include questions relating to the more pragmatic aspects of assuring successful participation in the test, such as: selective service classification; previous arrest history; health of close family members; impending parenthood or marriage; financial condition; life goals; preferences and aversions to food; a brief review of the medical history; occupation of parents with special reference to hazardous occupations; health of parents and immediate health history; technical skills and aptitudes based upon previous work or hobby history; history of previous psychotherapeutics; and unusual or foreign accents or language difficulties. Interviews will be conducted by the Test Medical and Crew Integration Directors.

Twelve to fifteen of the applications will be selected on the basis of the personal interview to undergo an FAA Class II Flight Physical Examination. Those not eliminated for medical reasons will then undergo psychodiagnostic testing.

Psychodiagnostics will consist of objective tests administered by personnel of MDAC and scored and interpreted by a consultant licensed as a psychologist in the State of California. The objective psychodiagnostic test battery will include (1) MMPI, (2) Edwards Personal Preference Schook, (3) FIRO-B, (4) Allport-Vernon Study of Values, (5) Sixteen PF, Forms A and B, (5) Rokeach Dogma Scale, and (6) the Rotter I-E Scale or the Hidden Figures Test.

Results of the objective psychodiagnostics will be used in combination with the physical examination as a basis for the selection of six crew members to begin training.

8.1.2 Operating Staff

The operating staff will consist of three crews of five men each (Test Conductor, Medical Monitor, Communications Monitor, Engineering Monitor, and Technician). This staff, with the exception of the Medical Monitor, will be selected from a pool of personnel with extensive manned test experience. The operating staff must operate and maintain the facility, monitor and ensure crew safety, and effect those procedures that ensure effective mission performance with the required data collection and analyses. The training program will be designed to update the staff's knowledge of operations and provide a detailed protocol of test requirements.

Test Conductors will be selected by the Program Manager from engineers who have operation and subsystem design experience. Each Test Conductor will be responsible to the Program Manager for the overall functions of the staff, test protocols, and operation of the simulator and facility during his shift.

Medical Monitors will be selected by the Medical Director. They will be licensed physicians. Medical Monitors will be responsible for monitoring the health of the test crew, acquiring medical test data, maintaining a medical log, and handling medical emergencies.

Communications Monitors will be selected by the Crew Integration Director. The Communications Monitor will be responsible for the direction and control of all communication between the staff and the test crew. He will monitor crew activity via closed-circuit televesion at his console and initiate communication between the crew and operating staff members, principal investigators, and other manned test personnel who required communication with the crew. He will also be responsible for execution of the behavioral portion of the test protocol, including psychological evaluations and habitability studies, under the direction of the Crew Integration Director.

Selection of Communications Monitors has been given careful consideration from the viewpoint of minimizing or eliminating crew/support staff conflict. Such conflict is a consistent finding in flight simulations and confinement studies performed by various governmental agencies and industrial organizations. On the basis of results from previously conducted simulator studies, the following have been identified as possible causative factors in the conflict: divergent group affiliation and aggressiveness on the part of individual communicators.

In order to minimize the effects of divergent group affiliation, all Communications Monitors will participate in choesion training with the crew. This training will be oriented toward the formulation of a choesive group of personnel composed of the on-board crew, support crew and operating staff.

To minimize the incidence of aggressive behavior by the operating staff members, potential Communications Monitors will be identified from among qualified engineering personnel who have either served successfully in past studies in roles requiring frequent communication with on-board crews or whose work history displays above average qualities of tolerance and ability to interact constructively with fellow employees. Furthermore, all Communications Monitors will be appraised of techniques for dealing with aggressive behavior should it arise on the part of the onboard crew.

The Engineering Monitor will be chosen by the Engineering Director from among experienced engineers with the goal of complementing the training and experience of the Test Conductor.

The Electrical/Mechanical Technician will be selected from the support personnel of the Engineering Laboratories. He will be responsible for the maintenance of the test facility equipment and data acquisition equipment.

After preliminary selection, the staff will undergo the formal training and certification described in Section 8.2. The distribution of staff personnel into their operating staff positions will occur as training nears completion and training requirements are met. The assignment of members to each of the operational staffs will be directed toward assembling four groups that are balanced in their experience and capabilities. Selection will be a joint function of the Program Directors, with final approval of the distribution the responsibility of the Program Manager.

8.2 CREW TRAINING

An integrated training program shall be conducted for the six crew members (on-board and backup) and for the five operating staff positions.

8.2.1 On-Board Crew

All crew members (on-board and backup) will be trained to perform inflight operations and maintenance; monitor human, environmental, and system parameters; perform experiments; and undertake such other activities as are necessary for personal well-being and safety.

8.2.1.1 Organization and Facilities

The Program Manager will appoint a senior instructor to manage training in each area and a Training Director to coordinate the overall program. The Training Director will be responsible for scheduling all pretest crew interactions with scientific and technical personnel. He will report to the Crew Integration Director. His duties include scheduling all training, monitoring training progress, providing subjective evaluations of crew, administering and scoring objective tests, providing advice on structuring of a viable crew, and assisting in orienting crew members to aerospace goals and attitudes.

Each instructor will prepare course outlines and measures of achievement. Instructors will specify minimum training standards and develop proficiency measures of the crew candidates. These measures will be used in certification and selection of the on-board crew and the assignment of specific mission task responsibilities.

8.2.1.2 Curriculum

The curriculum will consist of material relating to the three areas of interest within the program: life support system engineering, biomedicine, and crew integration. A similar curriculum is shown in Table 8-2, page 215, Reference 2. Three basic modes of material presentation will be employed: lectures, demonstrations, and practice sessions. Mode of presentation will be selected based on the course material to be presented.

8.2.1.2.1 System Design and Operation

Practice in LSS equipment operation will be conducted with the actual subsystems when they are available and in the classroom area at other times. A similar curriculum is presented in Reference 2, Section 8.2.1. The subsections from this reference that are appropriate to future tests are as follows:

Maintenance and Repair, Section 8.2.1.1
Data and Sample Collection, Section 8.2.1.2
Emergency and Safety, Section 8.2.2
Fire Control, Section 8.2.2.1
Communications System, Section 8.2.2.2
Psychomotor Testers, Section 8.2.3

8.2.1.2.2 Passout Procedures

While routine passouts will not be done, the crewmen will be trained in passout procedures for contingent or emergency events. Instruction will be given in operational techniques and the hazards in operation of the passout ports. It will be stressed that the passout procedures are to be conducted

according to established procedures. One crew member will be selected and assigned the responsibility of assuring proper function of the passout port and conducting passout operations. Sufficient training will be given other crew members to assure that passout procedures can be accomplished by all.

8.2.1.2.3 Crew/Computer Data Link

(See Reference 2, Section 8.2.5)

8.2.1.2.4 Exercise Program

During training, the crew will be required to learn the specific techniques required during rxercise and understand the importance of the measurements to be obtained. The significance of those measurements which require bioinstrumentation will be explained to the crew members and techniques of proper calibration and adjustment will be emphasized. The crew will be trained to a baseline level of physical conditioning of "good" to "very good" on the Balke Scale. Other evaluations and physical measures will be accomplished under the direction of biomedical personnel.

8.2.1.2.5 Housekeeping

Assignment of cabin housekeeping duties will be the responsibility of the crew commander. Housekeeping will consist of adhering to waste storage requirements, periodic vacuuming and sweeping of floor areas, collection of spilled liquids and dusting of work surfaces. Appropriate techniques for accomplishing all these functions will be taught to all crew members.

8.2.1.2.6 Hygiene

The amount of training in the Hygienics area is minimal and will consist of: appropriate storage of soiled towels, washcloths and implements, and correct use of laundry equipment. Procedures in the management of hygiene provisions will be stressed.

8.2.1.2.7 Food Management

Crew members will be instructed in the operation, radiation monitoring, and maintenance of the microwave oven for food warming. In addition, training will be given on food preparation and food waste management. Further instruction will include food consumption data handling through the use of the on-board computer link.

8.2.1.2.8 Cohesion Training

In addition to the basic training regimen, choesion training will be employed to develop a sense of group identity among crew members, improve sensitivity to the social and personal needs of both crewmen and operating staff, and generally promote effective interpersonal relationships among personnel inside and outside the chamber. These sessions will be conducted at the level of social awareness and will not delve into deep personal psychodynamics characteristic of group psychotherapy. The assumption is that each participant is psychologically "normal" but can benefit by getting to know other participants more quickly and efficiently through cohesion training sessions.

Participants in these sessions will include not only the candidate crewmen, but also certain operating staff members. The latter may include the Test Conductor, Medical Director, Communications Monitors, Engineering Monitors, and certain principal investigators (who will require frequent interaction with on-board crewmen).

Cohesion training will be conducted by a consultant who is a qualified psychologist in accordance with established State licensing requirements. Approximately 9 training sessions of varying duration will be conducted with the crewmen present at each session. Each member of the operating staff mentioned above will attend at least three of these sessions. The transactions that occur in all sessions will be held confidential. To that end, they will be conducted in either the medical support area or at the consultant's facility.

8.2.1.3 Evaluation

An objective rating system will be developed to assess training levels achieved by the candidates at various points in the program. This will be used to maintain a progress record for each crewman candidate throughout the training period and to identify areas for improvement within the training program. Instructors will fill out a proficiency rating form for each crewman (Table 8-3, Page 216, Reference 2); and the crewmen will rate the course, themselves, and other crewmen within each subject area (Table 8-4, Page 217, Reference 2). The crew will be asked for recommendations to improve the courses and to indicate areas for review.

Progress of each crewman during training will also be measured and recorded from a series of tests and retests. Practical and written tests will be administered throughout the training period. An examination covering all subject matter will be given one week after the beginning of training, again at the mid-point, and finally at the end of the training period.

8.2.2 Operating Staff

Training for the operating staff is an interdisciplinary function. The staff members require considerable cross-training in several areas, and specialists in each discipline will be assigned to develop curricula and lectures and to direct practice sessions so that each staff member meets appropriate proficiency levels for the 100-hour and extended manned tests.

There are varying degrees of -ross-training required among the staff members. For some genral operations the Test Conductor, the Communications Monitor, and the Engineering Monitor must be able to interchange positions with equal effectiveness. The Engineering Monitor will substitute for either the Test Conductor or the Communications Monitor when they must leave their stations. Emergency training will require cross-training of roles so that there will be an assurance of high reliability in the execution of the various modes of test operations described in Section 3.

Table 9-1, Page 228 of Reference 2, is a typical curriculum for staff members showing the required cross-training. Each of the training requirements for the staff, except for the Medical Monitor is outlined on Tables 9-2 through 9-10 of Reference 2. Table 8-1 is a copy of the certification record that will be completed for each staff member.

A Review Board consisting of the Engineering Director, Crew Integration Director, Medical Director, Engineering Laboratories Representative, and a Chairman appointed by the Program Manager shall review and approve all course content prior to course conduct. This Review Board shall review training results and certify all staff members.

Training of the Medical Monitors is a segregated function conducted under the supervision of the Medical Director and will include indoctrination on test protocols and functional requirements of the test. There need not be a formal certification record for Medical Monitors but the Medical Director will certify that they are physicians licensed to practice medicine in accordance with requirements of the State in which the test is performed, and are acceptable and qualified to perform the required medical monitoring functions.

8.3 CREW ACTIVITY SCHEDULING

A computer-generated schedule will be provided to the crew and operating staff for use as a management tool during the test. The ground rules and procedures described below will be used in the formulation and revision of the schedule.

8.3.1 Ground Rules

A two crewmen up and two crewmen down work/rest cycle will be used during the test with a crew time allocation of 8.5 hours for sleep, 2.5 hours for meals, 3.0 hours free time, and 10.0 hours for duty. Fixed time events will be as follows:

Table 8-1

FACILITIES OPERATION
TRAINING AND CERTIFICATION RECORD

NAME:________________ LOC/DEPT:________________ EMP NO.______

* *

I(we) attest that the individual named above has successfully satisfied the criteria established for the following course(s):

Course	Instructor	Date
SSS Familiarization		
Comm. Control Console		
LSM Console		
Gas Analysis Console		
Test Conductor Console		
Data System Operations		
Maintenance Procedures		
Test Operations		

* *

In view of the above, I hereby recommend certification of this individual for the following operating staff position(s)

____

____

Date	Training Coordinator

* *

________________ ________________

* *

Approved by:________________________ __________
Chairman of Training Review Board — Date
Extended Manned Test Program

a. Crewman 1 and Crewman 2: Sleep, 2400 to 0830 hours
Breakfast, 0900 to 0940 hours
Lunch, 1430 to 1520 hours
Dinner, 1940 to 2040 hours

b. Crewman 3 and Crewman 3: Sleep, 1500 to 2330 hours
Breakfast, 2400 to 0040 hours
Lunch, 0530 to 0620 hours
Dinner, 1100 to 1200 hours

No attempt will be made to schedule events during free-time periods; this time may be used by the crew for any individual activity they desire, such as work on personal research projects, sleep, or recreation. The nominal free-time period of three hours per day should be scheduled to allow as much consecutive free time as possible. When required, the nominal free-time period will be reduced for any specific day to permit scheduling of necessary activities.

Computer programmers, operations, and management personnel will maintain a close working relationship to insure a common understanding of all activities to be scheduled. This requirement is especially important as it applies to event constraints. Their correct interpretation and use is doubly important to prevent schedule conflicts since scheduling usually requires the participation of personnel from several discipline areas.

8.3.2 Procedures

The General Planning Model (GPL) and ONe Day Model (ODM), two of the models from the Langley Research Center Space Station Mathematical Simulation Model (SSMM), and associated procedures will be used to prepare the Crew Event Matrix, Mission Event Profile, and Crew Activity Schedule. A Crew Skill Matrix will be used as a source of input data for the GPM and ODM.

8.3.2.1 Crew Skill Matrix

The Crew Skill Matrix provides basic data required by the GPM for the generation of the Mission Event Profile. It will describe in broad terms the operational, maintenance/repair, biomedical, and special skills required by the crewmen to effectively perform their assigned tasks during the test. Table 8-2 may be used in initial planning. It will be updated to incorporate changes in assignment of primary and secondary skills for individual crewmen as crew taining progresses and as more becomes known of the individual skills of specific crewmen.

8.3.2.2 Crew Event Matrix

The data submittal format for the Crew Event Matrix should be similar to that of Table 12-1, Reference 2, in order to ensure that all essential data items are provided. The acquisition and formatting of Crew Event Matrix data will be accomplished using traditional methods during the initial phase of the program by interviewing engineering, medical, crew integration, experiment, and management personnel and by analyzing system and experiment descriptions. This will be a continuing effort from the beginning of the program with updating of the data until two weeks prior to start of the test. A final update will be completed after completion of the test.

8.3.2.3 Mission Event Profile

The Mission Event Profile, similar to that shown on Figure 12-1, Reference 2, will be generated by the General Planning Model of the SSMM computer program. This profile will be a schedule of crew activities for the entire 4 weeks, organized on a day-to-day basis. It will indicate which event will be active and the crewman who should perform each event for each mission day. Required input reference data are the given work/rest cycle and fixed time events, the Crew Skill Matrix, and the Crew Event Matrix. The GPM user's manual will be reviewed in detail prior to converting the reference data to required computer format. The GPM will be exercised to generate an initial profile six weeks after ATP, and to produce an updated, final profile two weeks prior to test start.

TABLE 8-2

CREW SKILL MATRIX (SAMPLE)

		Crewman (CM)			
		1	2	3	4
1.	Mechanical	2	2	1	1
2.	Electrical/Electronics	2	1	2	1
3.	Microbiology	1	1	2	2
4.	Biochemistry	1	1	2	2
5.	Medical Treatment	2	2	2	2
6.	Photography	1	1	1	1
7.	Utility	1	1	1	1
8.	Special, Requires CM 1	1	0	0	0
9.	Special, Requires CM 2	0	1	0	0
10.	Special, Requires CM 3	0	0	1	0
11.	Special, Requires CM 4	0	0	0	1

1 - Primary Skill, 2 - Secondary Skill, 0 - No Skill

8.3.2.4 Crew Activity Schedule

The Crew Activity Schedule, similar to that of Table 10-4, Reference 2, will be generated by the One Day Model of the SSMM computer program using the following as standard input data: Crew Event Matrix, Mission Event Profile, and test plan ground rules. Each event listed on the Crew Event Matrix will be shown on the Crew Activity Schedule by number and event name, as appropriate. It will indicate the events which are active on a given day; the crewman who should perform the task; the time of day when the event should be performed, with events required to comply with operational and experiment constraints; and the total time for the event. Block scheduling will be used, when appropriate; e.g., the event "Biomed Checks" is a block of activities which includes taking a sample of the first urination of the day, taking and recording body temperature, and obtaining body weight; these activities will be scheduled as a block - Biomed Checks - and will be shown as such on the schedule. The ODM user's manual will be reviewed in detail prior to converting the reference data to required computer format. The ODM will be exercised to generate an initial Crew Activity Schedule seven weeks after ATP, at mid program, two weeks prior to test start, during the test if the crew commander requests assistance in effecting major changes to the schedule, and after test completion to incorporate test results.

8.4 HABITABILITY SUBSYSTEM

This subsection describes the Habitability Subsystem to be provided for the Phase A test, identifies design requirements for each of the subsystem elements, and discusses the methodology to be used in evaluating the adequacy of the design.

8.4.1 Habitability Subsystem Elements

The Habitability Subsystem to be provided within the chamber for the 4-week test consists of the following elements:

1. Volume and Space (general configuration)
2. Food Management
3. Personal Hygiene and Laundry

4. Recreational Provisions
5. Crew Furnishings and Accommodations
6. Sleep Facilities
7. Housekeeping and Waste Collection
8. Lighting and Decor
9. Clothing and Linens
10. Atmospheric Conditions
11. Storage Facilities

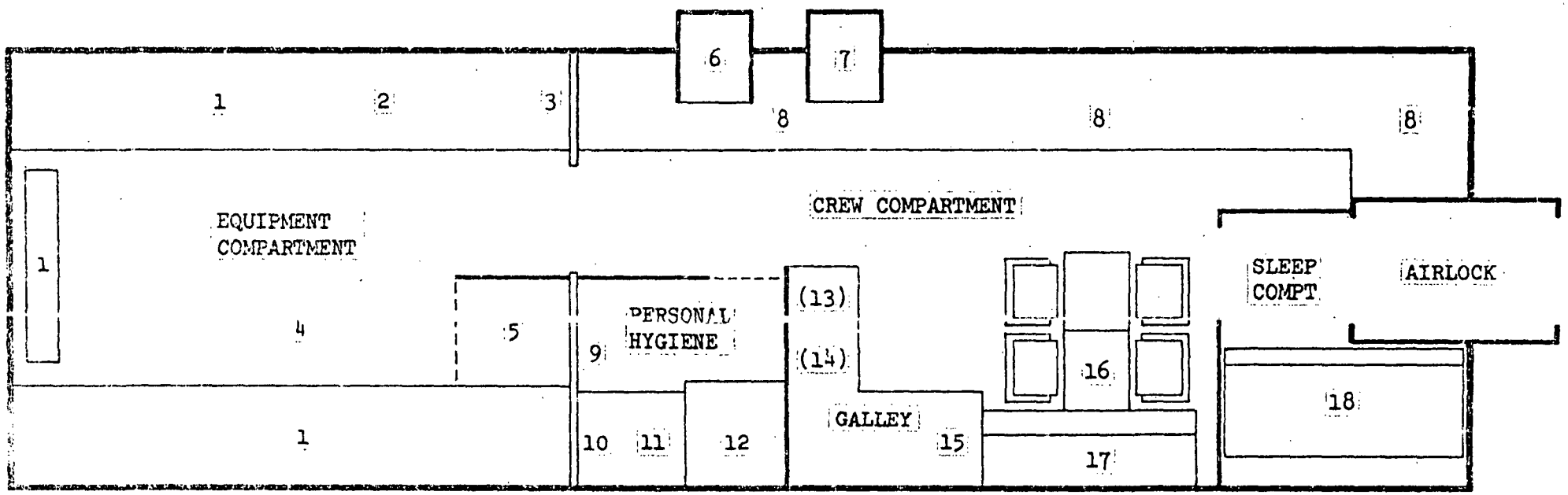
8.4.2 Design Characteristics

Habitability design will be based upon the basic habitat used in the 90-day test, improved in accordance with results of that test. Consideration in design will be given to the fact that test duration is shorter, some of the onboard crew activities will be different, and accommodations may have to be made for mixed crews.

8.4.2.1 Volume and Space

The general configuration of the chamber interior has been recommended upon the basis of previous test experience as applied to future test requirements. A conceptual layout of a recommended chamber is shown in Figure 8-1. For the chamber shown in this layout, the equipment compartment will provide a gross volume of 42 m^3 (1500 cu ft) with a minimum of 7.43 m^2 (80 sq ft) of floor space. The crew compartment will have 58.8 m^3 (2100 cu ft) gross volume and 9.3 m^2 (100 sq ft) of free floor space. The gross volume of the sleep compartment will be 14.0 m^3 (500 cu ft) with 1.2 m^2 (13 sq ft) of free floor space. The airlock with 4.12 m^3 (147 cu ft) volume adds 1.86 m^2 (20 sq ft) of floor space. Floor to ceiling height in all areas in which crewmen will be standing shall be a minimum of 1.98 m (78 in).

An acoustical bulkhead will be provided between the crew and equipment compartments. All equipment which may require maintenance will be located and installed for ease of access.



1. LIFE SUPPORT SYSTEMS
2. SPARES
3. MAINTENANCE/TOOLS
4. ERGOMETER
5. COMMODE/URINAL
6. CHEMICAL STORAGE
7. AUTOCLAVE
8. ONBOARD LAB
9. WASHER
10. DRYER
11. SINK
12. SHOWER
13. REFRIGERATOR
14. FREEZER
15. MICROWAVE OVEN
16. RECREATION/DINING
17. CREW LIFE SUPPORT MONITOR
18. BUNKS (2)

FIGURE 8-1. SIMULATOR REDESIGN CONCEPT

8.4.2.2 Food Management

Design requirements for the food management subsystem are discussed under the headings of diet identification, packaging, preparation techniques, utensils, management of food waste, and data collection.

8.4.2.2.1 Diet Identification

Consistent with needs for variety, the menu shall be repeatable no more frequently than once per week.

Foods shall be selected with regard to acceptability by potential crew members, who will be the final judges of acceptability. Taste tests shall be conducted prior to finalization of batch preparation and delivery. Food will be evaluated from the standpoint of color, texture, flavor, and aroma. Excessive preparation (reconstitution, heating) time will be avoided.

A basic diet of freeze-dried, non-compressed food will provide approximately 10.460 MJ (2500 Kcal) per man per day and will be supplemented by snacks providing approximately 2.09 MJ (500 Kcal) per man-day. All food shall be nutritionally balanced in accordance with NAS/NRC recommendations for carbohydrate, fat, protein, minerals, and vitamins. Where necessary, suitable supplements will be provided. Food composition in respect to carbohydrate, fat, protein, calcium, and phosphorus shall be documented (including snack items). Dry and wet weights and caloric content of each menu will also be documented.

Bacterial standards for food items will be determined in consultation with NASA authorities and in accordance with current NASA standards.

8.4.2.2.2 Packaging

Food packaging materials will be evaluated and selected on the basis of flammability, outgassing, and gas permeability criteria.

8.4.2.2.3 Preparation Techniques and Equipment

Preparation will consist of rehydrating and heating. All reheating of cooked foods will be performed with a microwave oven. As backup, an appropriately modified hotplate will be provided.

The microwave oven is a Litton Industries Model 500 unit which employs microwave electromagnetic energy to heat food directly, within a few minutes, without an intervening heat-transfer media. A magnetron tube produces the microwave energy which is directed into the oven cavity. Within the oven cavity, the electromagnetic energy is absorbed by the food and is converted directly into thermal energy uniformly throughout the food mass.

An interlock prevents the oven from operating unless the door is latched. Interlocks also prevent the oven from operating when either the front or rear access panel is removed. The oven circuits are protected by a circuit breaker and a fuse. A thermal protector prevents the magnetron tube from overheating.

A Narda Model 8100 survey meter will be provided to permit the crew to make periodic checks of the microwave oven door seal for radiation leakage. Any reading in excess of 5 mv/cm^2 will require readjustment of the door seal before the microwave oven can be used. This repair shall be done only with concurrence of the Test Conductor.

Design operating requirements for the microwave oven are as follows:

Power Source:	110 to 125 vac 20 amp 60 Hz, single phase
Power Input:	Standby - none Idle - 275 watts Cooking - 2,200 watts
Power Output:	1,000 watts nominal of rf microwave energy, operating at a frequency of 2,450 MHz

8.4.2.2.4 Utensils

Reusable dishes and eating utensils will be employed. All implements will be made of Teflon or be heavily coated with Teflon over a substrate compatible with microwave or hot plate utilization. A list of utensil requirements may be developed from Table 5-5, Reference 2, with adjustment of quantities proportional to mission duration and other changes such as elimination of the disposable dishes.

8.4.2.2.5 Management of Food Waste

Remnants of food on Teflon implements will be handled in the following manner:

1. Crew members will be encouraged to minimize the food waste management problem by consuming all foods.
2. Dry food remnants will be placed into dry storage utilizing the trash storage container.
3. Dishes and utensils containing wet food remnants will be placed in the microwave oven. The oven will be activated for a duration necessary to dessicate remnants. Dishes and utensils will be removed from the oven and divested of dried waste through scraping. Waste will then be placed in empty food packages.
4. Dried wastes and food packaging will be placed in the trash storage container.
5. Dishes and utensils will be stored in a cabinet especially designed to expose them to ultraviolet irradiation. The UV source will automatically activate upon cabinet closure for a predetermined duration.

Wet waste products other than food will be treated by canning as accomplished during the 90-day test. No bacteriostat will be employed. Instead, cans of wet waste will be autoclaved after sealing and will be stored onboard for the remainder of the test.

8.4.2.2.6 Data Recording and Collection

After each meal, food remnants will be weighed in the dishes from which they were consumed. After weighing all items, each crewman will record each food item consumed, remnant weights, and a numerical acceptability rating using a teletypewriter keyboard and a cathode ray tube display.

8.4.2.3 Personal Hygiene and Laundry

A partitioned area in the Crew Compartment (Figure 8-1) will contain the onboard shower, oral hygiene equipment, and clothes laundering apparatus.

Wash water recovery capability will permit daily showering by each crew member and weekly clothes/bed linen laundering.

The personal hygiene equipment and supplies which will be provided may be derived from Table 5-2, Reference 2.

A large glass mirror will be located within the personal hygiene area and two additional small portable mirrors will be provided.

Laundering equipment will consist of a commercial clothes washer and electric dryer located in the personal hygiene area. Cleansing agent for laundering is TBD.

8.4.2.4 Recreational Provisions

A high fidelity stereophonic music system will be provided featuring onboard tuning of AM-FM commercial broadcasts, onboard record and playback of magnetic tape, and permitting private or group listening to auditory material.

A commercial color television will also be provided onboard.

A library of approximately 75 books will be provided representing selections made during training by the crew. Ample writing materials will be available and board games as requested by the crew.

Provisions will be made for the crew to make private commercial telephone calls.

8.4.2.5 Crew Furnishings and Accommodations

A table and four chairs will be provided in the Crew Compartment. The table will be 0.56 m (22 in) wide and 1.32 m (52 in) long by 0.71 m (28 in) high, will be attached to the wall of the chamber and will have capability of being partially stowed when not in use. Chairs will be sufficiently comfortable for use in eating, studying, and relaxing.

Two chairs will be provided for use in the Equipment Compartment. They will be adjustable for working at the various work spaces in this compartment.

Microphones and headsets will be provided. Two microphones will have a press-to-talk feature.

Privacy accommodations will be satisfied by design of sleeping quarters which permit individual seclusion in a bunk. Private areas in addition to the bunk area will be limited to the body-hygiene area and the waste management area. All of these three areas will also be free of observation and monitoring equipment, such as video cameras and microphones.

8.4.2.6 Sleep Facilities

Sleeping accommodations will consist of two bunks, each of which will be used by two crewmen since the work/rest cycle will permit only two crew members to be scheduled for sleep at any one time. Each crew member will be provided with a bedroll for his personal use to be stored in or near the bunk area. Each of the bunks will be enclosed to prevent light leaks from disturbing sleeping crew members.

8.4.2.7 Housekeeping and Waste Collection

The housekeeping and waste collection functions to be supported by this element include general cleaning of compartment interior walls and surfaces, collection and storage of refuse (excluding urine and fecal waste), periodic cleaning of hardware items such as the microwave oven, and periodic replacement and disposal of filters and other elements.

The required housekeeping/waste collection and storage equipment/supplies are shown in Table 8-3. These items will be installed and stowed within the compartment for ease of access, convenience of use, and portability where required.

Table 8-3

Housekeeping/Waste Collection and Storage Equipment/Supplies

Item	Quantity
Trash Storage Container	1
Canner	1
Food Scrapers	2
Dust Pan	1
Broom, Brush, or Whisk Broom	1
Ladder (6')	1
Cleaning Rags (Size TBD)	TBD
Fluorel Sponge, closed cell	1
Large Sponges	6
Paper Towels	TBD
Vacuum Cleaner	1
Detergent (Type TBD)	TBD

8.4.2.8 Lighting and Decor

Lighting and decor will be utilized to enrich the crew habitat, provide variety, give distinctiveness between living and working areas, and promote effective, pleasant accomplishment of crew tasks.

8.4.2.8.1 Lighting

Fluorescent lighting fixtures will be provided for general lighting in the equipment and crew compartments. Capability will be provided in each compartment for the crew to adjust general illumination levels to a maximum of 30 foot candles. Partitioned areas, such as personal hygiene and waste management, may be supplied with supplementary lighting. Illumination of the bunk areas will be limited to incandescent portable personal reading lamps.

8.4.2.8.2 Decor

Materials and surface treatments of surfaces normally visible will be selected using criteria of flammability, outgassing, noise attenuation and visual diversity and interest. Colors and materials used in the various areas will be selected to provide a sharp distinction between living quarters, laboratory, and equipment areas.

8.4.2.9 Clothing and Linens

Clothing will be of Nomex and be tailored to be commodious. Material selected will meet requirements of minimum particle generation, reflectivity compatible with video monitoring light levels, non-allergenicity, fabric strength, laundering, flammability, outgassing, and warmth (clo value) necessary for use within the cabin atmospheric environment. Undergarments will be made of cotton. Footwear will consist of cotton socks and leather moccasins; the latter will be soft-soled and heelless. Pajamas or other sleep garments will be provided for each crew member.

Bed linens will be selected from the same standpoints as clothing, but will increase clo values to approximately 2.0-2.5. Materials will be non-slip or sewn to minimize slippage.

Towels and washcloths of cotton terrycloth will be provided.

8.4.2.10 Atmospheric Conditions

Temperature in the chamber will be maintained at 294 $\pm$ 1.5°K (70 $\pm$ 5°F) and relative humidity at 40-70%. Air flow rates shall not exceed 0.017 m^3/sec (25 cfm), but may be increased in localized areas. Capability for adjustment of air flow in the sleep area will be provided to control the rate of evaporative cooling of the body during sleep.

The acoustic environment within the chamber shall conform to the criteria shown in Figure 8-2. The acoustic bulkhead between the equipment and crew compartments shall provide an attenuation of at least 6 db in the overall sound pressure level between the two compartments.

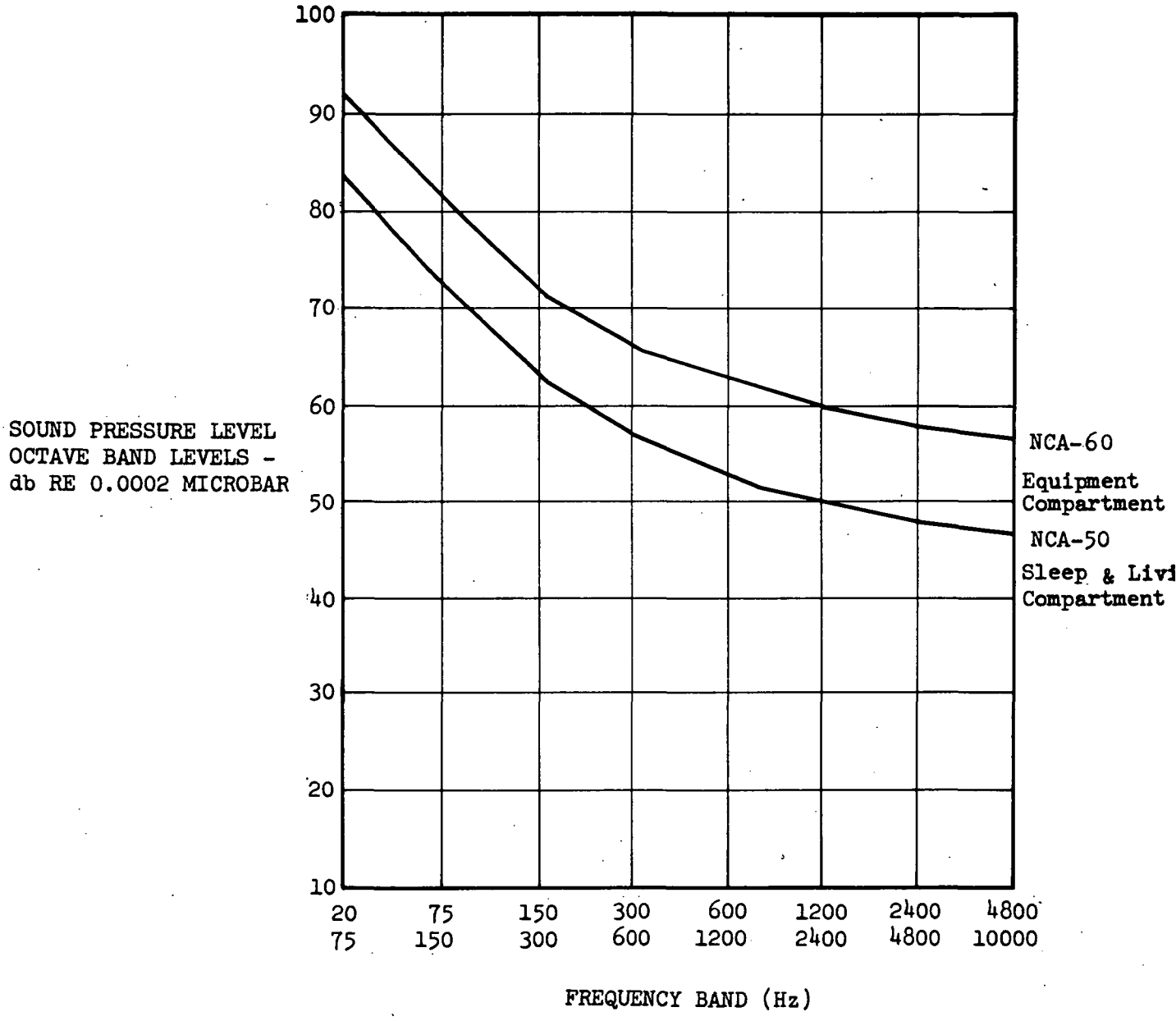


FIGURE 8-2. NOISE CRITERIA CURVES

8.4.2.11 Storage

All loose equipment, food, tools, etc., will be assigned a storage space. Figure 8-3 will be used as a starting point for such assignment for a chamber having the configuration shown in Figure 8-1.

8.4.3 Habitability Assessment

The assessment program for evaluating design adequacy of the Habitability Subsystem will have as its objective determination of the onboard crew's responses to each of the Habitability features described above, in terms of satisfaction or dissatisfaction, feelings of comfort or discomfore, and modifications necessary for long-term occupancy. The assessment program will include:

1. Subjective responses from crewmen obtained pretest, periodically during the test, and immediately following the test.
2. Objective measures of frequency of use of facilities, direct observations of difficulties encountered in using facilities, and verbal or other expressions of annoyance with specific Habitability features.
3. Periodic measurements during the test of environmental variables including illumination, sound levels, temperatures, humidity, and air flow.

A Habitability assessment questionnaire similar to that used on previous manned tests (e.g., Tektite I and MDAC 90-Day Test) will be developed. It will include items relating to volume and space, food management, environment, hygiene and laundry provisions, recreational facilities, crew furnishings and accommodations, sleep facilities, lighting and decor, housekeeping, waste management, storage, and clothing. Each item will require an evaluation on a four-point scale. Questions will be responded to by the crew once prior to the actual test (perhaps during the 100-hour test), once each week during confinement, and once post-test. During the actual test, crew members will respond to the questionnaire by keyboard inputs to the crew/computer data link. In the training program, each potential crewman will be fully informed of the rationale for the Habitability questionnaire and trained in procedures

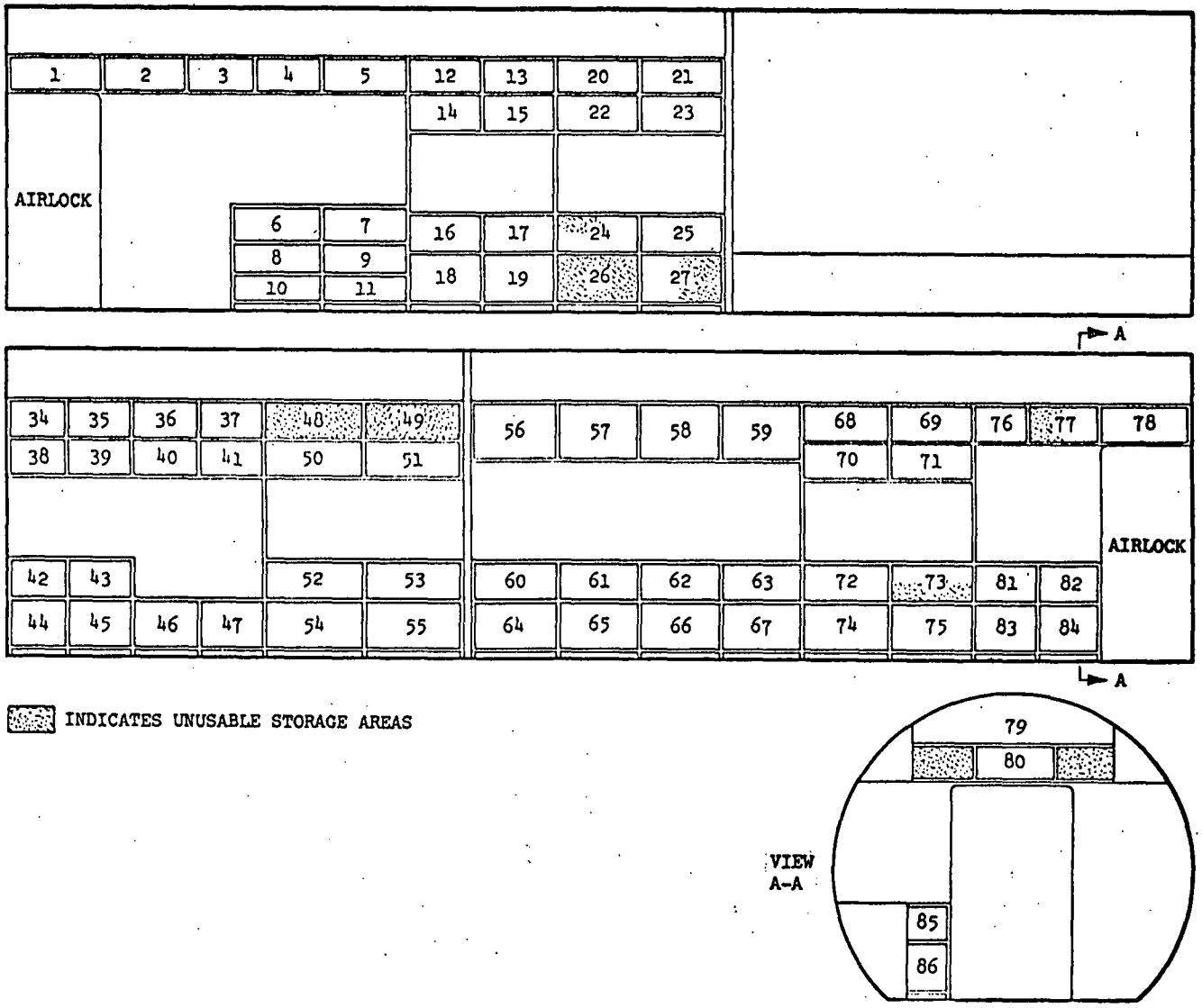


FIGURE 8-3. STORAGE AREAS

for completing it. A portion of the post-test debriefing will be devoted to obtaining crew members' detailed reactions to the various Habitability pro visions.

During the test, observations will be made by outside monitors of the frequency of use by crew members of those Habitability features in which the crew has a choice either to use or not use the facilities. These observations apply to such items as recreational choices, food choices, and garment selection. Observations will also be made and recorded of physical problems in using Habitability provisions and verbal behavior indicative of satisfaction or dissatisfaction with facilities.

Following the test, detailed inspection and operational check of the chamber furnishings and facilities will be performed to determine how well the Habitability provisions survived the 4-week test period. This inspection and check will concentrate on unusual wear and tear, evidence of equipment abuse, operational deterioration, and changes in appearance.

Data collected in the Habitability assessment program will be systematically analyzed to assure that all facets of assessment have been considered. Means of crewmen evaluations for each Habitability feature will be computed and changes over time will be determined. These changes will, where appropriate, be compared with measured changes in environmental parameters. Pre- and post-test data and observational data collected during the test will be considered in the analysis.

8.5 BEHAVIOR ASSESSMENT

Data will be collected to privide measures of various aspects of human behavior as they interface with the manned test program. Two primary sources of data will be available: observations by outside personnel and onboard recordings by crew members. These observations will be augmented by reivew of keyboard output by onboard crew members and through post-test debriefings.

8.5.1 Observations by Outside Personnel

Behavioral data will be available from the Communications Monitor Crew Status Log. This log will be structured to provide subjective impressions of crew behavior that will be entered at the end of a shift. These data are of the type that may be useful to staff members on the next shift, as well as of general interest. The information will be included in the post-test analysis to supplement other behavioral data.

8.5.2 Onboard Recording by Crew Members

Onboard crew behavior data will be gathered from three sources: (1) psychomotor task data, (2) personal crew member diaries, and (3) responses to questionnaires.

Psychomotor test devices will feed data via hardwire to the outside to provide hardcopy records. Additionally, crew members will be asked to keep personal diaries to provide data for post-test analysis. They will be encouraged to enter observations on crew interactions, personal feelings toward other crew members and outside personnel, feelings related to dealings with the opposite sex, recreational desires, and subjective feelings of task pressure. Although this structure will be provided, it will be emphasized that any thoughts whatsoever are legitimate entries for the personal diary. Thus, any subjective feelings that a member wishes to express will be considered valid.

A keyboard link (crew/computer data link) will be used to transmit certain data to the outside. The data include responses to questionnaires regarding food consumption, work accomplishment, sociometry, sleep, and habitability. In addition, the keyboard link will be used to transmit data necessary for mass balance determinations. The output of the keyboard will be immediately available to the outside staff as a hardcopy record.

8.5.3 Work Performance Assessment

The hardcopy received as keyboard output will be reviewed daily for information regarding the quality of crew performance. Information such as total number

of uncorrected transmitted errors, corrected errors, and total number of alphanumeric entries per crew member will be extracted from this hardcopy and appropriately tabulated as supporting information on crew performance quality.

8.5.4 Post-Test Debriefings

Immediately following the 100-hour test and the four-week test, a series of debriefings will be conducted with the crew. An Engineering Debriefing will be held for all staff personnel. A closed Behavioral Debriefing will also be held. Attendance at the latter debriefing will be limited to staff members who are directly responsible for crew behavioral matters. Finally, additional debriefings may be conducted for specific interests; for example, as they relate to particular experiments.

Section 9

MEDICAL PROGRAMS

9.1 PRETEST PROCEDURES

The pretest procedures outlined here do not include selection criteria. For those, see Section 8.

9.1.1 Training

All crew members, including backup crew members, will be trained in onboard medical procedures under the direction of the Test Medical Director. The Medical Director will be responsible for certification of the training.

9.1.2 Initial Medical Screening

All candidates will be given a physical examination equivalent to an FAA Class II Flight Physical as specified in FAR-67 with waivers as appropriate (female candidates being afforded a gynecological consultation). Routine urinalyses and hematological examinations will also be performed as part of screening.

9.1.3 Pretest Medical Evaluation

Those candidates successfully passing the initial medical screening and psychodiagnostics will be further evaluated with the following medical tests:

Blood

1. CBC with RBC indices
2. Bleeding and clotting time
3. VDRL
4. PBI
5. Calcium
6. Inorganic phosphorus
7. Glucose, fasting and 1/2, 1, 2, 3, 4, and 5 hours post-ingestion 100 gm glucose

8. Blood Urea Nitrogen
9. Uric Acid
10. Cholesterol
11. Total Protein
12. Albumin
13. Bilirubin, direct and indirect
14. Alkaline phosphatase
15. SGOT
16. LDH

Urine

1. Specific gravity
2. Sugar
3. Protein
4. Ketone
5. pH
6. Occult Blood
7. Microscopic
8. Culture

Microbiology

1. Nasopharyngeal microflora
2. Stool (ova, parasites, occult blood, and salmonella)

Physical Evaluation

1. Pulmonary spirometry
2. Stress electrocardiogram
3. Exercise tolerance (treadmill)
4. Body composition, including body water compartments (methods TBD)
5. Clinical EEG
6. Dental examination

9.1.4 Pretest Baselines

Microbiology

1. Nasopharyngeal Samples

Samples of nasal and oropharyngeal microflora will be taken from all members of the prime and backup crews. Samples will be taken semi-weekly commencing 28 days prior to day 1 of the test.

2. Potable Water Samples

Samples from the potable water system will be taken and assayed as required to insure the acceptability of the system in regard to microbial control.

Hematology

Fasting blood samples (2-hour minimum post-prandial) will be taken at 0800 and 1600 hours every Monday and Friday for 4 weeks immediately preceding test start. All primary and backup crewmen will participate. The analyses to be performed are as follows:

1. Hemoglobin
2. Microhematocrit
3. White Blood Cell Count
4. Red Blood Cell Count

Analysis will be initiated shortly after the samples have been obtained. Two blood smears per sample will be prepared and stored for later analysis.

Biochemistries

Fasting blood samples (2-hour minimum post-prandial) will be taken at 0800 and 1600 hours every Wednesday for 4 weeks immediately preceding test start. Serum will be separated from the clot by centrifugation and stored at 253°K for later analysis. All primary and backup crewmen will participate. The analyses to be performed are as follows:

1. Alkaline phosphatase
2. Bilirubin, total
3. Glucose

4. BUN
5. Cholesterol
6. Calcium
7. Inorganic phosphorus
8. Uric Acid
9. Total protein
10. Albumin
11. SGOT
12. LDH

Analysis will be delayed until all pretest specimens have been obtained.

Urine

A 10-20% aliquot of each 24-hour urine volume will be obtained, daily, from all primary and backup crew members for 2 weeks immediately preceding test start. The urine specimens will be held frozen at 253°K throughout the collection period. Analysis will be delayed until all pretest samples have been obtained. Analyses to be performed are as follows:

1. pH
2. Titratable acidity
3. Ammonia
4. Na^+
5. K^+
6. Cl^-
7. Ca^{++}
8. $PO_4^{\equiv}$
9. Specific gravity

Pulmonary Spirometry

All crew members and backup crew will be trained to asymptote on the pulmonary spirometer.

Contingency Samples

Blood

A portion of the serum obtained from all primary and backup crew members for biochemistries will be stored at 203°K for contingency analyses.

9.2 TEST PROCEDURES

9.2.1 Test Medical Support

A fully equipped Emergency Resuscitation Facility will be located adjacent to the Test Facility. There will be one licensed physician on duty at all times in the immediate area of the Test Facility. These physicians will be selected and trained by the Test Medical Director.

9.2.2 Biomedical Sampling and Analyses

Microbiology

1. Nasopharyngeal Samples

Samples of nasal and oropharyngeal microflora will be taken from all crew members semi-weekly during the test. The nasopharyngeal swabs will be streaked onto plates of appropriate culture media for semi-quantitation and detection of medically significant bacteria:

Staphylococcus aureus
Diplococcus pneumoniae
Neisseria meningitidis
Hemophilus influenzae
streptococcus - beta hemolytic

2. Potable Water Samples

At least 48 hours prior to switching to a new potable water tank, water samples will be taken from the tank and from other points as required for microbiological certification. The samples will be processed with a Millipore Field Monitor which will be incubated with the appropriate media and examined onboard for total count.

Hematology

Fasting blood samples will be taken by the primary crewmen once per week shortly after arising. The blood samples will be analyzed onboard shortly after collection for:

1. Hemoglobin
2. Microhematocrit
3. White Blood Cell Count
4. Red Blood Cell Count

Two blood smears per sample will be prepared and stored for later examination.

Serum Samples

A fasting blood sample will be obtained in conjunction with the hematology specimens indicated above. The blood will be allowed to clot, the serum will be separated by centrifugation and transferred to appropriate storage containers for on-board preservation at 253°K.

The backup crew members will be sampled simultaneously with the primary crew using the same materials and techniques as that employed onboard. These specimens will be stored at 253°K for post-test analysis the same as pretest.

Urine Samples

All primary and backup crew members will collect a 10-20% aliquot of each 24-hr urine daily throughout the test. The specimens will be stored onboard and outside at 253°K for post-test analysis the same as pretest.

Pulmonary Spirometry

Pulmonary spirometry will be performed on each crew member once weekly.

Fecal

Feces will be tested for occult blood weekly.

9.3. POST-TEST PROCEDURES

Microbiology

Nasal and oropharyngeal sampling will be conducted post-test, twice weekly, for 28 days.

Hematology

The sampling protocol and schedule employed pretest will be repeated during the immediate post-test period; i.e., all crewmen will be sampled over a 4-week period, 3 sampling days per week, 2 samples per sampling day, at 0800 and 1600 hours. The blood specimens will be analyzed shortly after they have been obtained.

Biochemistries

The sampling protocol and schedule employed pretest will be repeated during the immediate post-test period; i.e., all crewmen will be sampled over a 4-week period, 1 sampling day per week, 2 samples per sampling day. The blood specimens will be allowed to clot, the serum will be separated from the clot by centrifugation and transferred to suitable storage containers for preservation at 253°K. Analysis will be delayed until all post-test specimens have been obtained.

Urine

The sampling protocol and schedule employed pretest will be repeated during the immediate post-test period; i.e., all crew members will collect a 10-20% aliquot of the 24-hour urine volume, daily, for 2 weeks immediately post-test. The specimens will be held frozen (253°K) throughout the collection period and analysis will be delayed until all post-test samples have been obtained.

Pulmonary

Pulmonary spirometry will be performed immediately post-test and one week post-test.

9.4 DATA REDUCTION

Appendix G constitutes a preliminary test plan for reduction of medical data. The sampling frequency shown in Appendix G is not that of the baseline program but illustrates the most extreme case for experimental design.

Section 10

SPECIAL STUDIES

Special medical, crew integration, and engineering studies, over and above those required for the insurance of crew health and safety and for documentation of test results, will be described in this Section when definition is obtained.

Section 11

INSTRUMENTATION AND DATA MANAGEMENT

This section describes the instrumentation and data management procedures formulated for the manned tests. Instrumentation will be provided for the life support systems, man systems and biomedical systems. Data management will include visual display with limited manual recording and/or automatic recording for all systems. In addition, test logs will be maintained and selected critical data will be displayed in a special area near the Test Control Area.

11.1 LIFE SUPPORT SYSTEM INSTRUMENTATION AND DATA MANAGEMENT EQUIPMENT

Life support instrumentation will be provided on all units in sufficient detail to allow complete evaluation of their performance throughout the manned tests. Schematics of all baseline units and supporting thermal conditioning, with instrumentation indicated, are shown in Figures 11-1 through 11-7. Readout will consist of visual display and/or automatic recording. Visual displays will be provided outside the simulator primarily on Cathode Ray Tubes (CRT), Life Support Monitor (LSM) and Gas Analysis Console (GAC). The LSM and GAC will also act as signal conditioners for data being collected automatically. A crew Life Support Monitor (CLSM) and a CRT will be located within the SSS where visual display will be available for critical equipment parameters. This instrumentation display will be sufficient in detail to allow the crew to perform a mass balance by use of the computer link.

11.1.1 Instrumentation List

A complete identification list of all instrumentation for the baseline units used in the manned tests is provided in Appendix E. Appendix E also contains

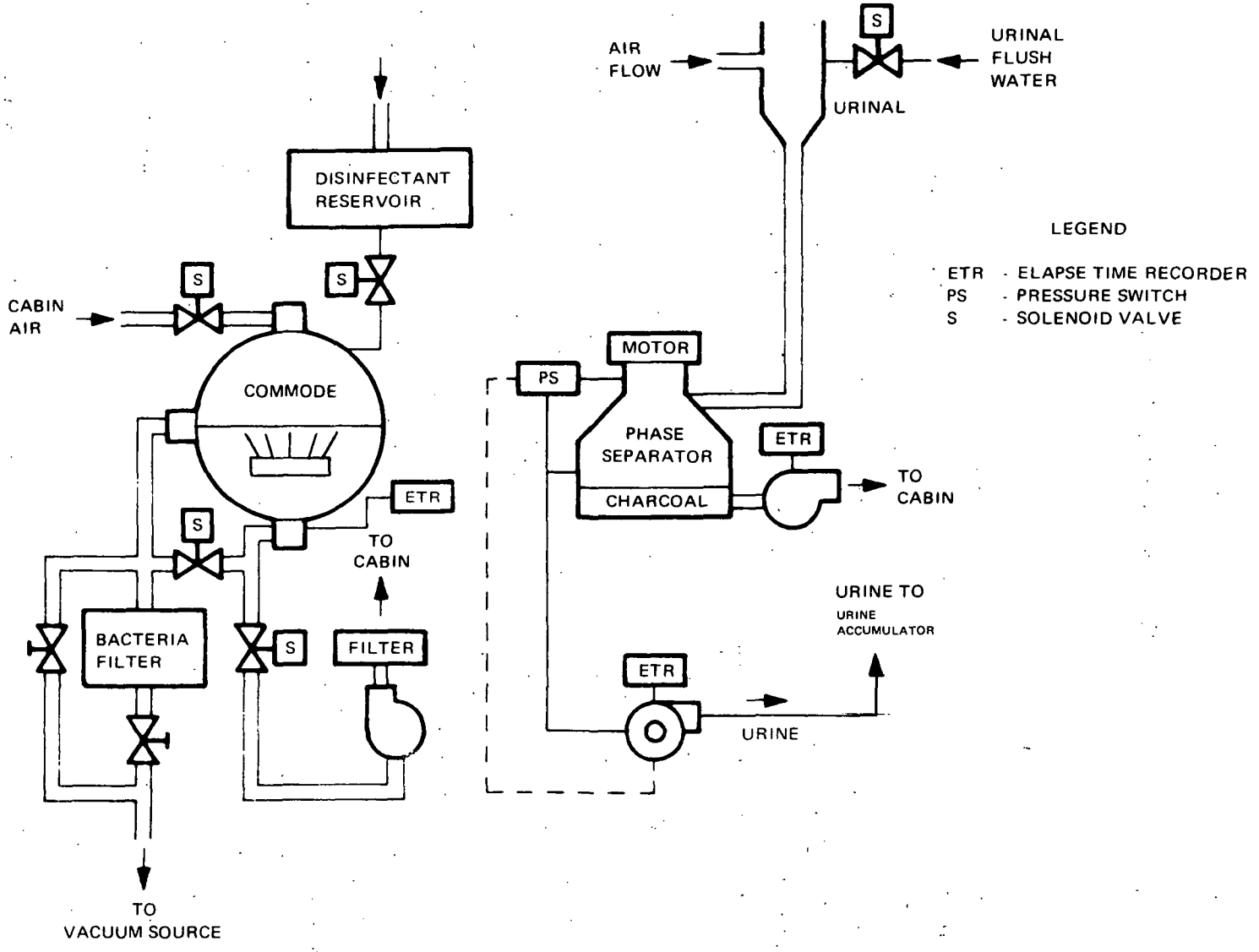


FIGURE 11-1. WASTE MANAGEMENT SUBSYSTEM COMMODE UNIT/URINE COLLECTOR UNIT INSTRUMENTATION SCHEMATIC

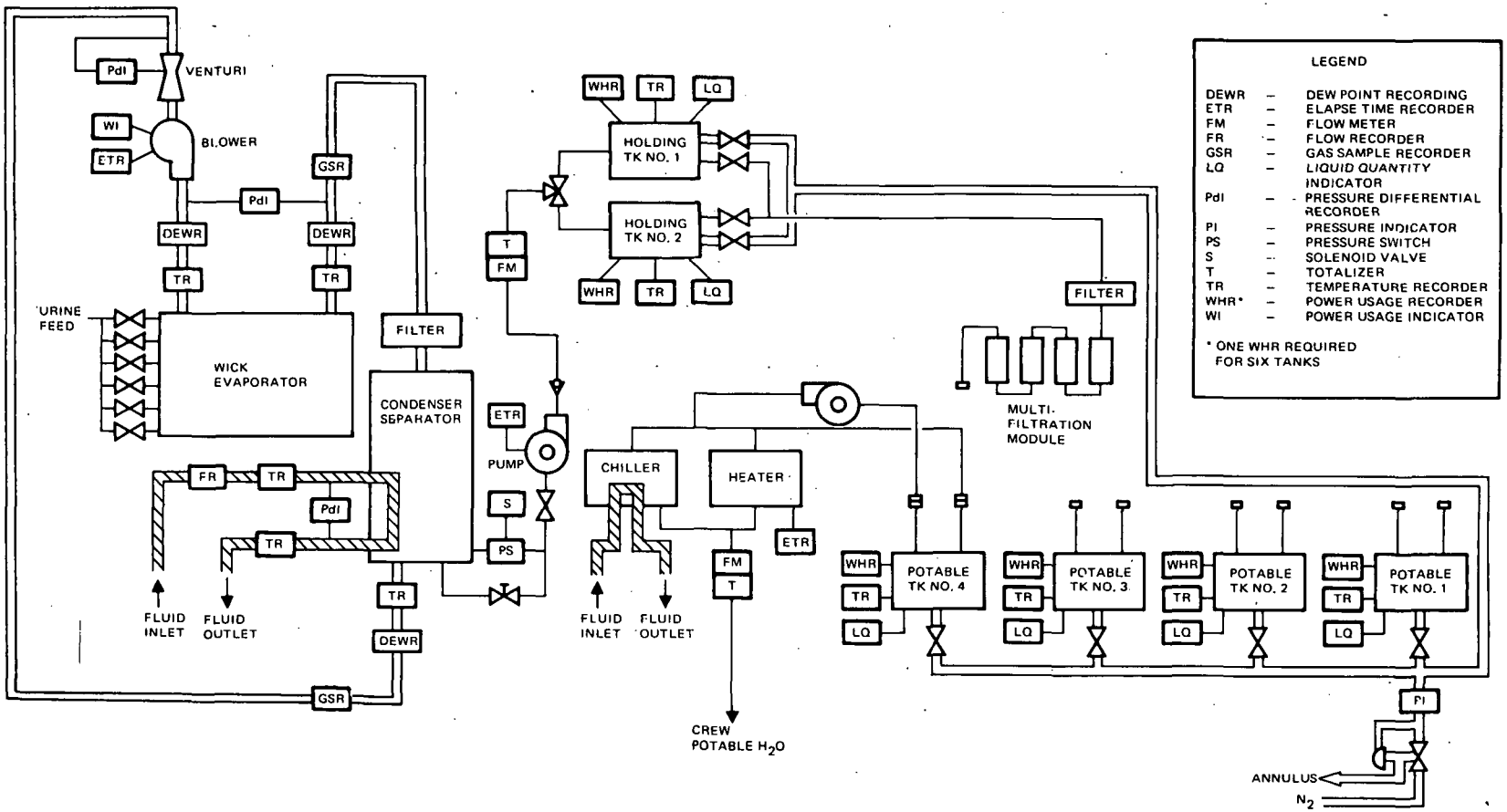


FIGURE 11-2. POTABLE WATER RECOVERY UNIT INSTRUMENTATION SCHEMATIC

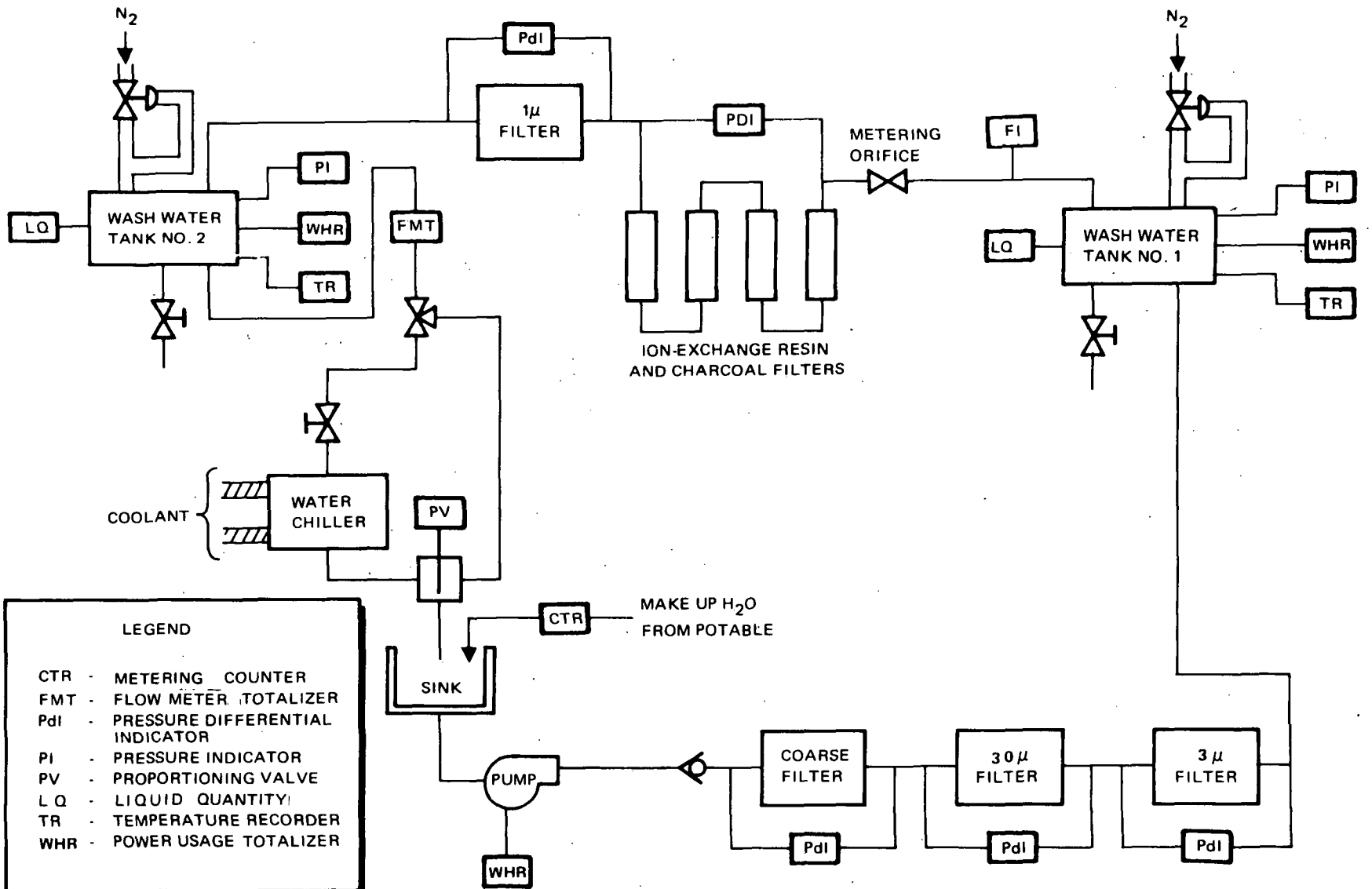


FIGURE 11-3. WASH WATER RECOVERY UNIT INSTRUMENTATION SCHEMATIC

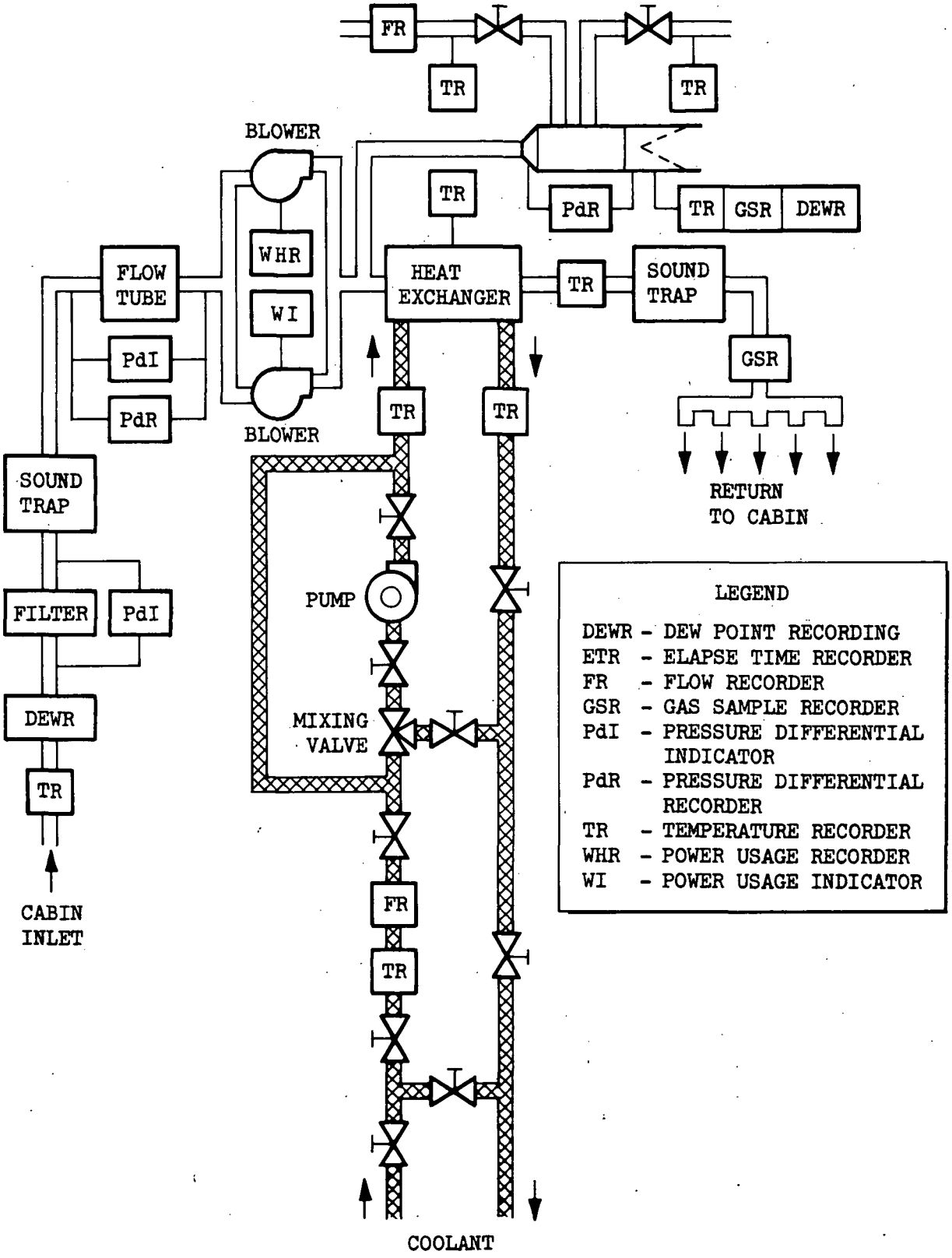


FIGURE 11-4 THERMAL-HUMIDITY CONTROL UNIT INSTRUMENTATION SCHEMATIC

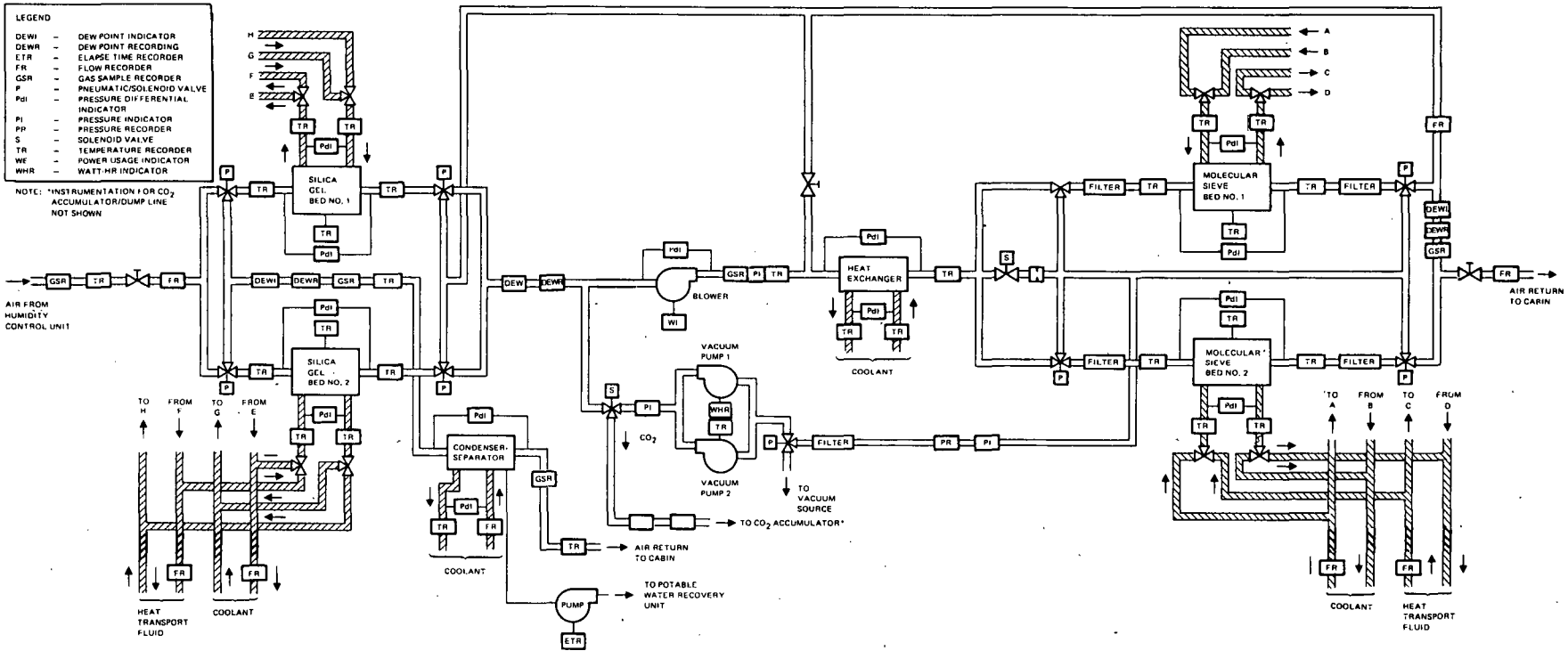


FIGURE 11-5. CARBON DIOXIDE CONCENTRATOR UNIT INSTRUMENTATION SCHEMATIC

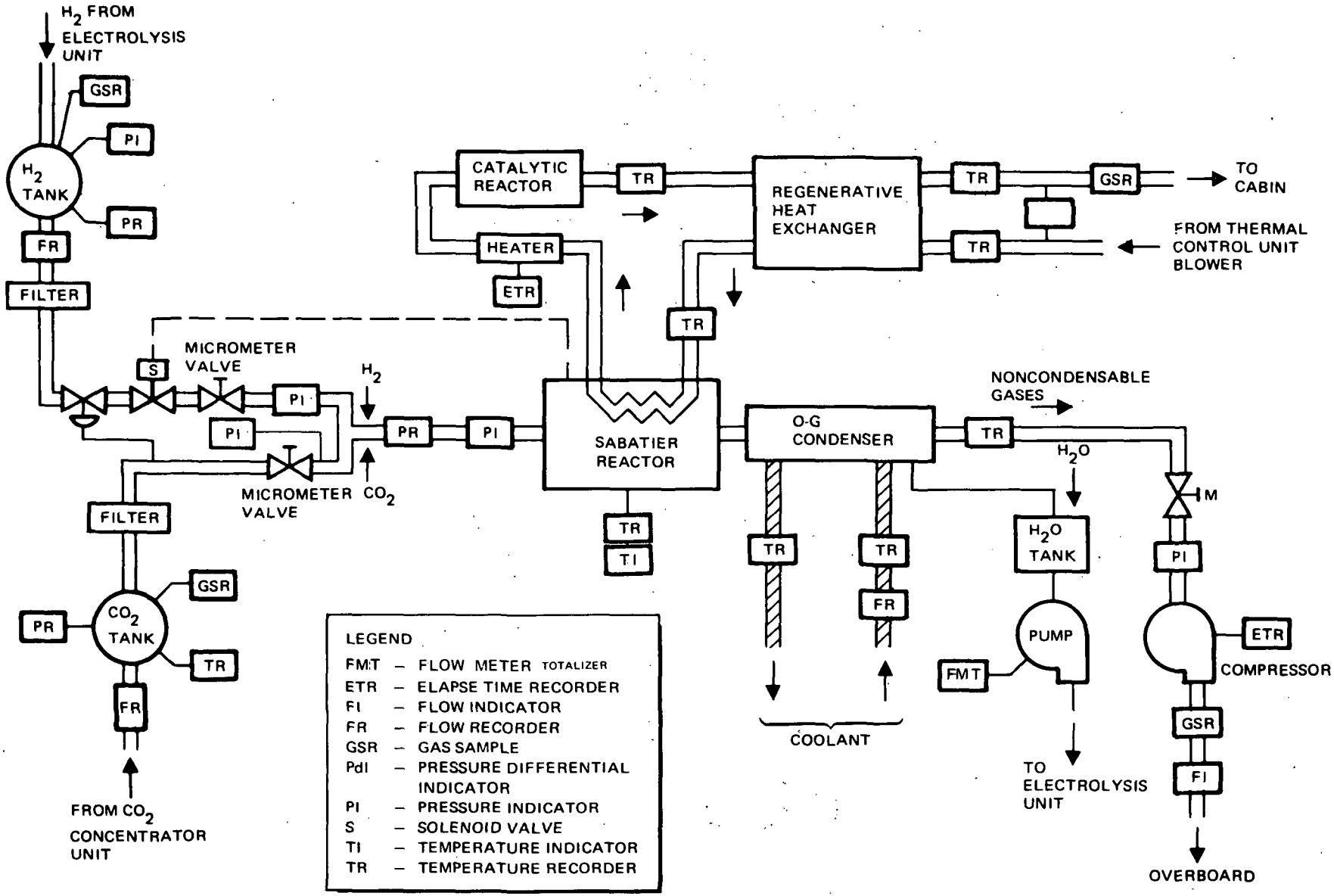


FIGURE 11-6. SABATIER REACTOR/TOXIN CONTROL UNITS INSTRUMENTATION SCHEMATIC

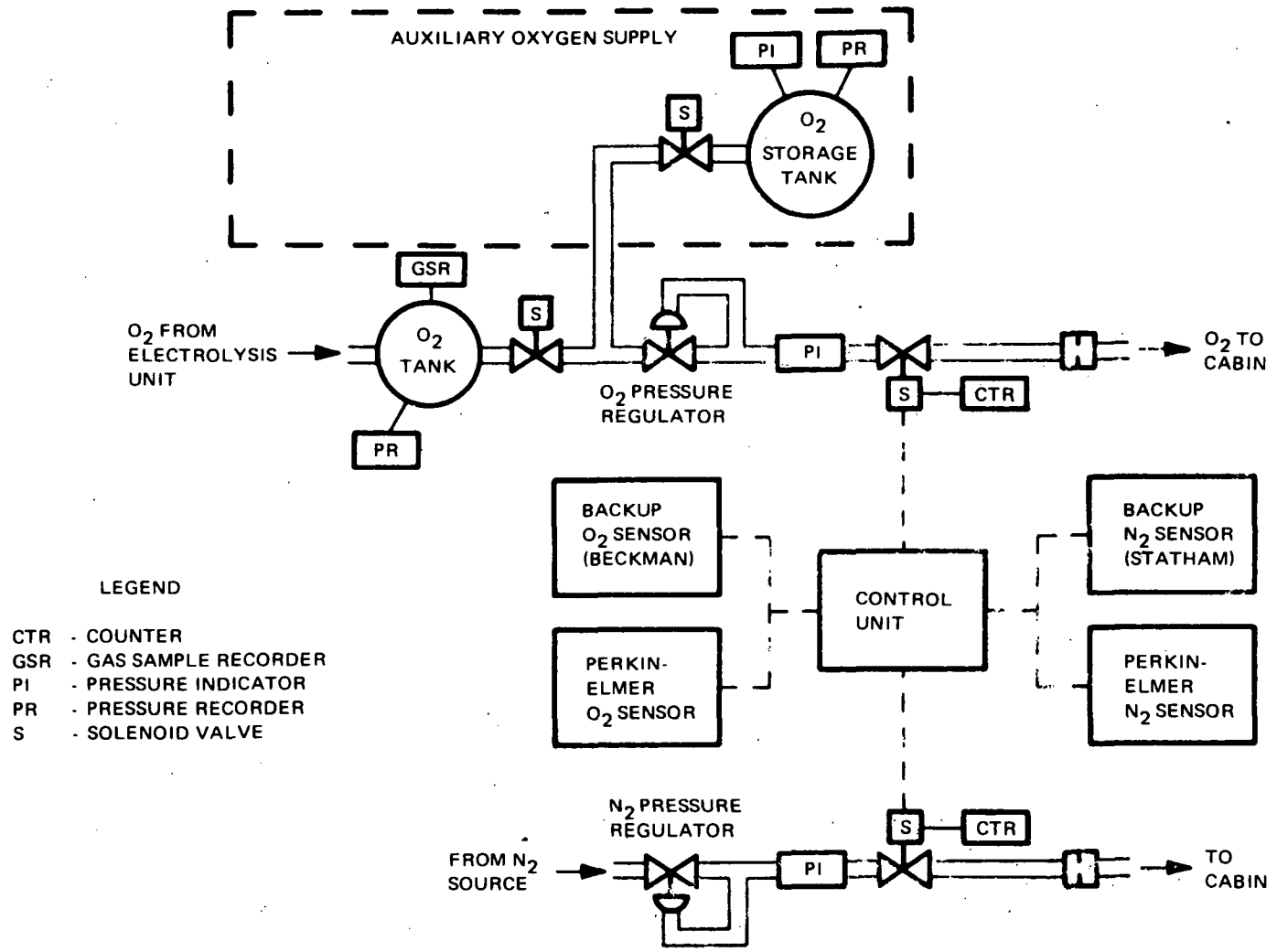


FIGURE 11-7. TWO-GAS CONTROL INSTRUMENTATION SCHEMATIC

selected instrumentation for some proposed advanced subsystems. This instrumentation identification list contains the description, location, readout location and the utilization of each piece of instrumentation.

11.1.2 Data Processing Computer

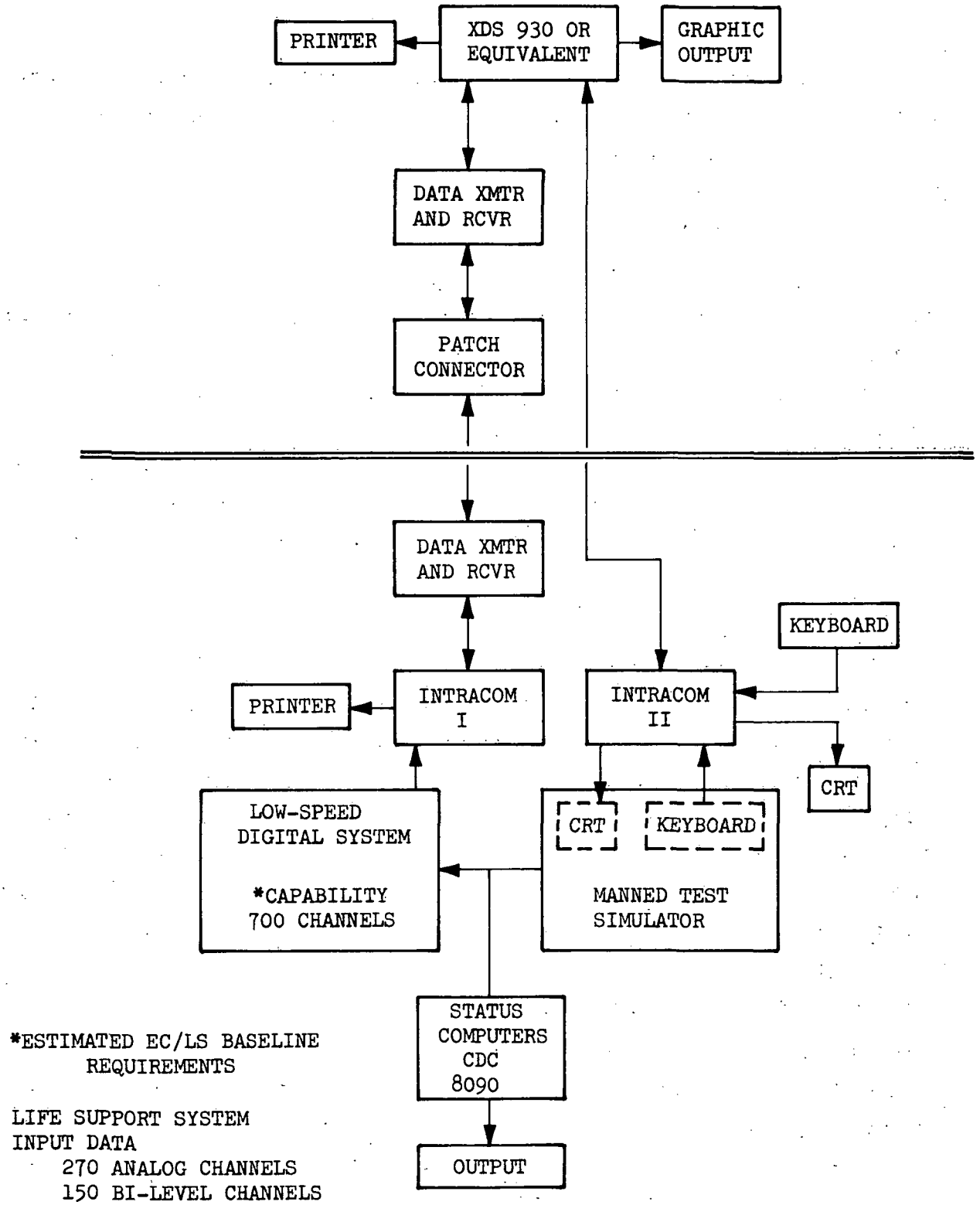
An XDS 930 or the equivalent will be utilized for data management. The peripheral equipment will be a data multiplexor, tape drives, a random access disk and a printer. A tape unit is necessary for storing bulk data and the disk is required for processing background data. The printer is needed for hard copy. In addition to the main process computer an auxiliary computer will be utilized with capability similar to a CDC 8090. The auxiliary computer will provide full time monitoring of system status and initiate status lights and/or alarms for out-of-tolerance parameters. A schematic of the data management system is shown in Figure 11-8.

11.1.3 Manual Data Entry and Display

Two CRT displays will be utilized for display of selected data. One will be located on-board for display of data to the crew and another will be located adjacent to the test conductors area. Selected data processed by the main computer will be displayed to the CRT's at the request of the staff or crew. The display request will be initiated via a keyboard (one on-board and another in the test control area). The keyboard is also required for entering manual data for which automation is either impossible or impractical.

11.1.4 Life Support Monitor (LSM)

The LSM, located in the Test Control area, will be used as a backup to monitor temperatures, flows and pressures from units inside the simulator. Figure 11-9 is a typical photograph of a LSM. It will be made up of cabinets which incorporate displays, meters, warning lights and gages with limited recording capability for some data parameters. Warning lights and/or audible alarms will also act as a backup to the auxiliary computer to monitor critical parameters of the subsystems involved with life support of the crewmen and control of their environment.



*ESTIMATED EC/LS BASELINE REQUIREMENTS

LIFE SUPPORT SYSTEM
INPUT DATA
270 ANALOG CHANNELS
150 BI-LEVEL CHANNELS
BEHAVIORAL INPUT DATA
50 ANALOG CHANNELS
MEDICAL INPUT DATA
50 ANALOG CHANNELS

FIGURE 11-8 INFORMATION SYSTEM EQUIPMENT SCHEMATIC

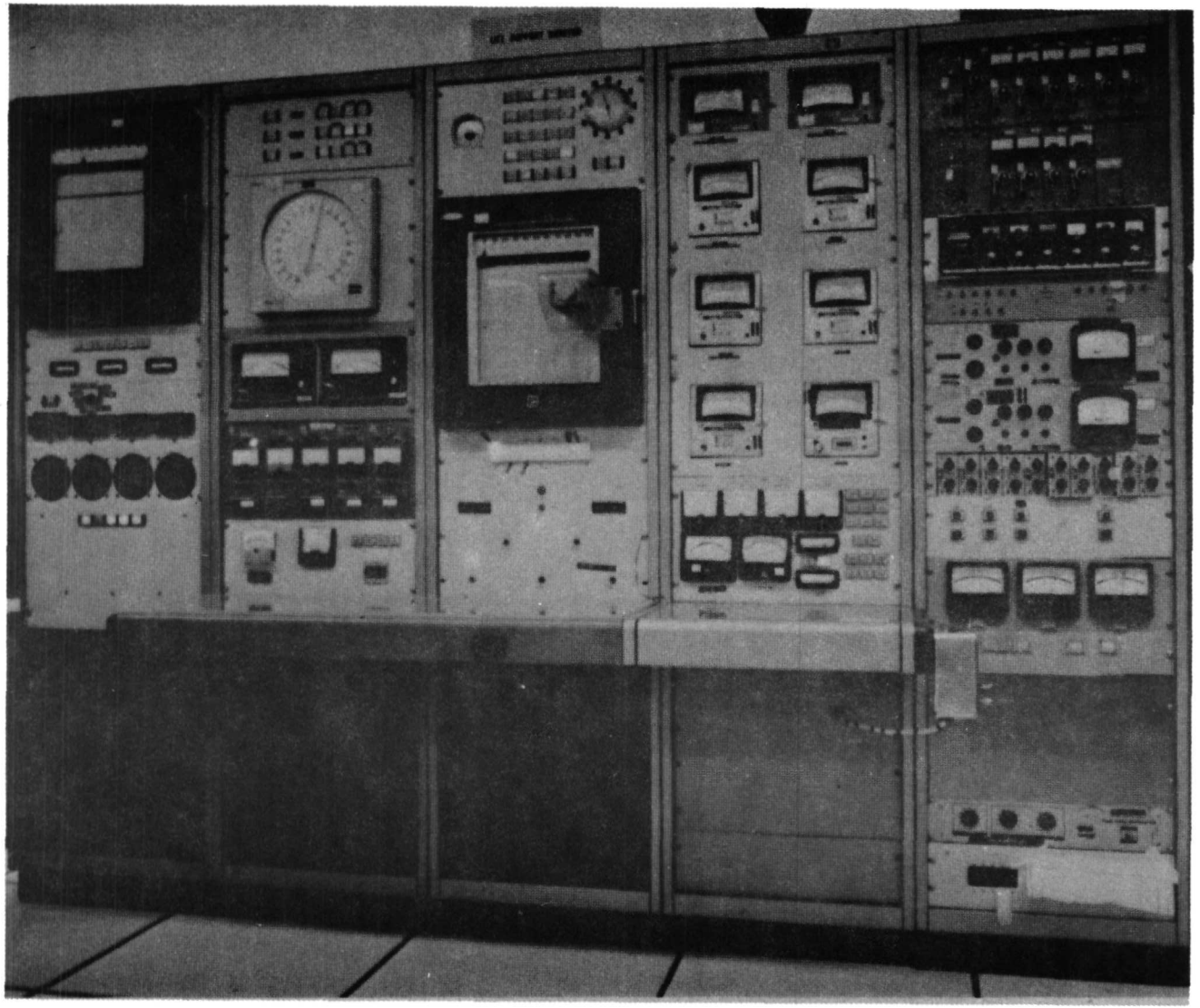


FIGURE 11-9 LIFE SUPPORT MONITOR

11.1.5 Crew Life Support Monitor (CLSM)

The CLSM will be used by the crew to monitor the critical parameters of the life support system. Digital readout will be provided for flows, pressures, temperatures and O_2 and N_2 usage. Status indicating lights will also be used to provide warning when a critical life support parameter is detected to be out of the normal range of operation. Monitoring of the CLSM will be provided by a crewman on command duty. A description of instrumentation that may be included in the CLSM is shown on Table 13-1, Reference 2. Figure 13-15 of Reference 2 shows a typical CLSM. The CLSM will be located in the living area of the test chamber where it can be observed from the dining/recreation table. Calibration will be made by comparing readouts on the LSM with those from the CLSM. Backup capability will be in the form of onboard spare switches, voltmeters and transducers.

11.1.6 Gas Analyzer Console (GAC)

The GAC will be used as signal conditioning to the automatic data system and will continuously monitor the inside cabin atmosphere and the performance of several life support subsystems such as the toxin control unit; atmosphere sensing, supply and control subsystem; the CO_2 concentration unit; and the water management subsystem.

The GAC contains three infrared analyzers, one flame-ionization hydrocarbon analyzer and one paramagnetic oxygen analyzer. The three infrared analyzers measure the CO_2, CO, and water vapor concentration. A multipoint strip-chart recorder located on the LSM provides a continuous on-line printout for the five analyzers.

The GAC interfaces with the test chamber by a continuous flow sampling loop. Within the chamber is a multiple station sampling manifold. Each sample tube is equipped with a solenoid valve which may be activated from the LSM. Station identity data are fed to the strip-chart recorder. The analysis system contains in-depth backup capability. The sample loop contains redundant circulation compressors. Spare infrared CO_2 and hydrocarbon analyzers are available, as well as backup capability provided by the onboard four-gas mass spectrometer and several gas chromatographs.

11.2 DATA MANAGEMENT PROGRAMS

Computer programs will be utilized which are compatible with the data management hardware described in Section 11.1. Status of the required software is as follows:

Existing On-Line Software

- Executive Program
- I/O (including keyboard processor)
- Fortran Processor
- Utility Programs

New On-Line Software

- Real Time Data Processing Routines
  - [NOTE: May be generated by modification and elaborating upon previously used programs.]

Existing Off-Line Software

- Assembler Program
- Fortran Processor
- Data Base Routines
- Data Processing Routines
- Utility Programs

New Off-Line Software

- Diagnostics Programs

11.2.1 Mass Balance Subroutine

The mass balance subroutine developed for the 90-day test will be modified and improved. System schematics indicating instrumentation for both gaseous and water mass balances are shown on Figure 11-10 and 11-11. Values from flow recorders, metering pump elapsed time recorders and other totalizing transducers will be entered by the crew on a daily basis via the keyboard. The balance will be computed, printed and displayed on the CRT's. Also displayed will be predicted values for comparative purposes.

11.2.2 Food Subroutine

After each meal, each crewman will be required to report the amount of food and water that he ingested. He will enter his identification number and the meal number eaten. The computer program will display the food items for that meal number. The crewman then enters the weight of the items uneaten and the amount of water added to each item. The computer program provides daily averages of ingested food weight, calories, and water. This process is repeated for each meal eaten.

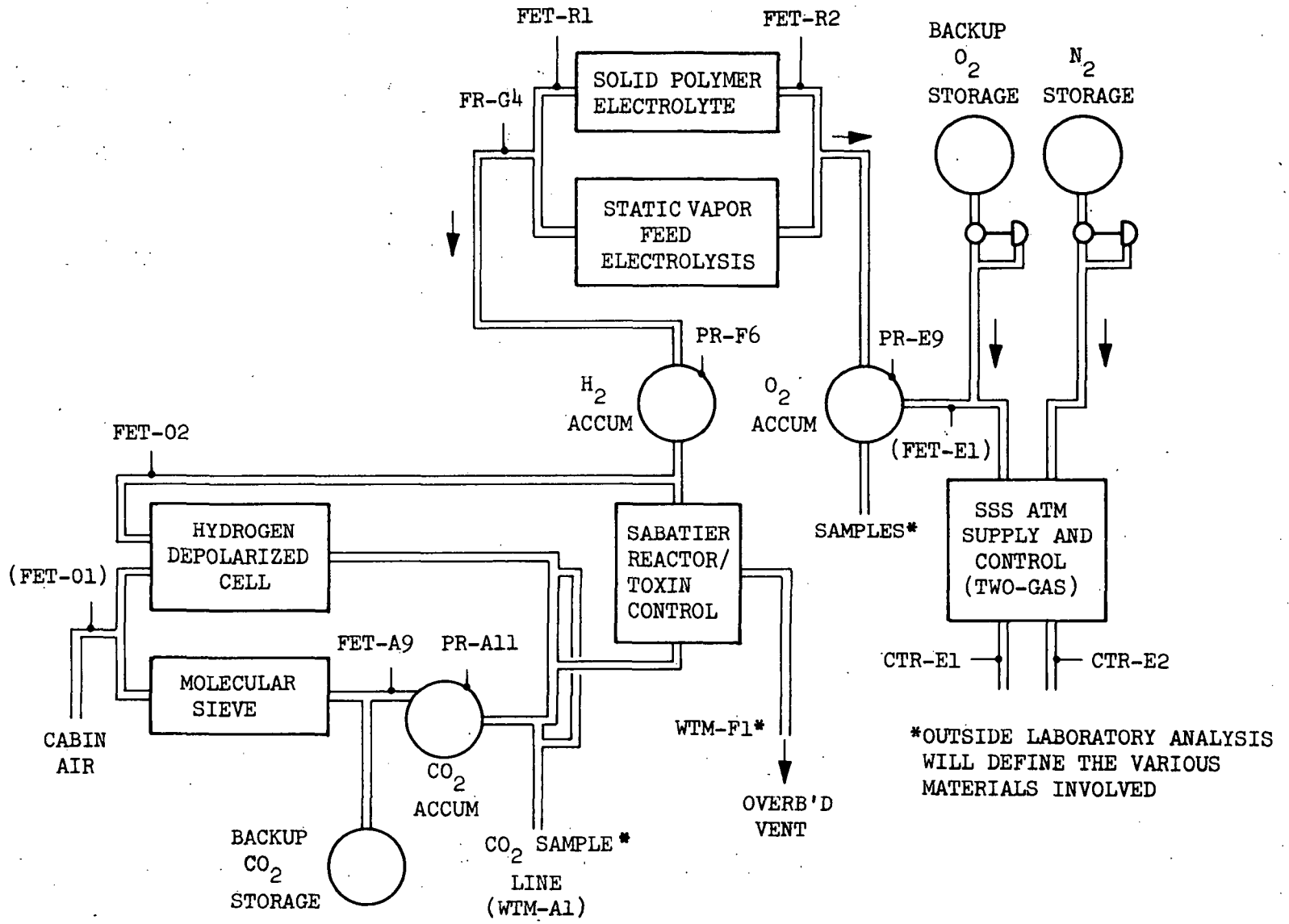


FIGURE 11-10 GASEOUS MASS BALANCE INSTRUMENTATION

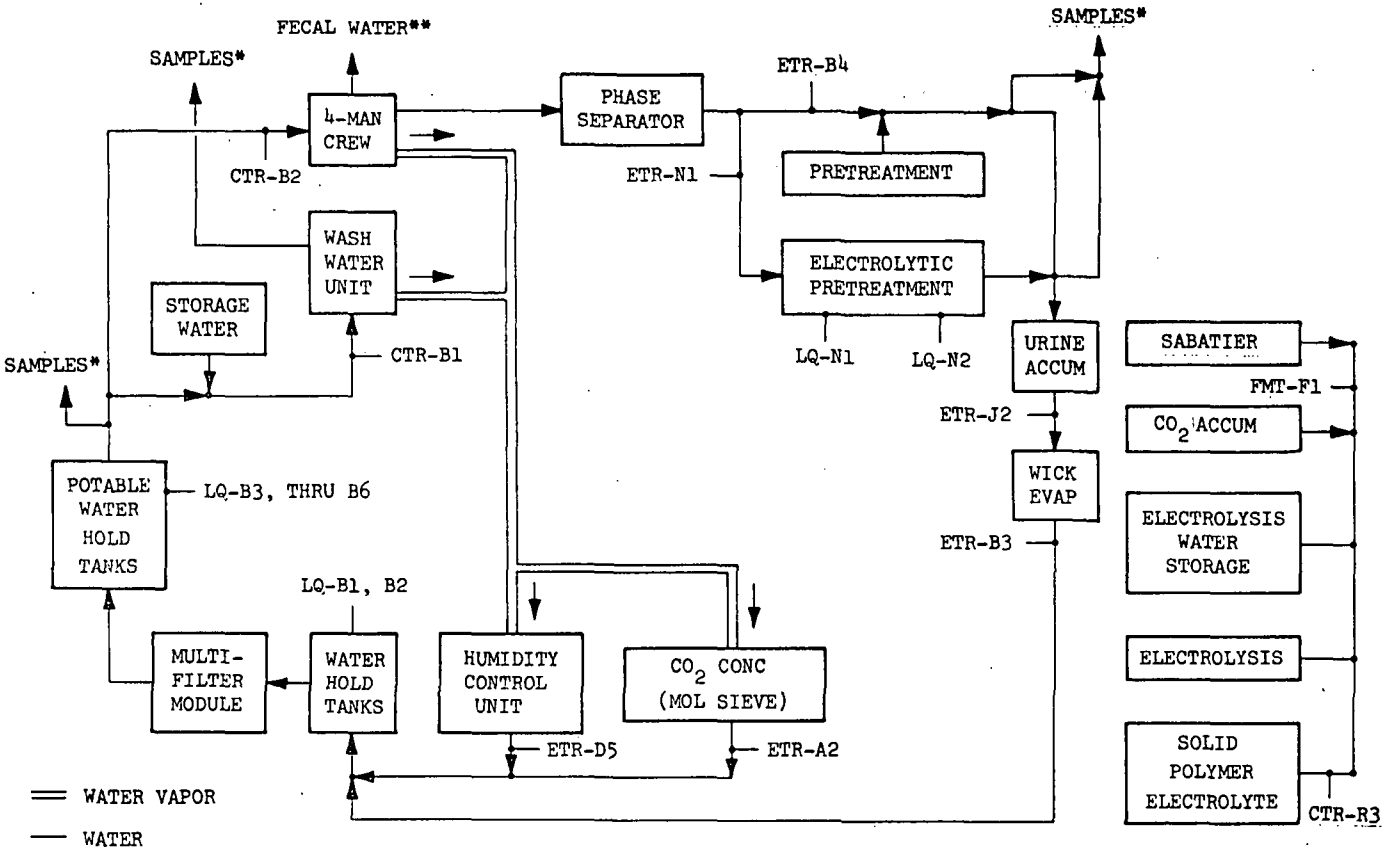


FIGURE 11-11. GROSS OVERALL WATER BALANCE INSTRUMENTATION

11.2.3 Questionnaire Subroutine

The questionnaire subroutine will be used to determine the psychological effect of prolonged confinement on the crew. Listed below are the questionnaires and their scheduled use during the test.

1.	Sociometry - assesses changes in sociometric preferences (group structure).	Every week starting with first week.
2.	Habitability Assessment Questionnaire.	Every week beginning with first week.
3.	Sleep questionnaire - assesses qualitative aspects of sleep.	Daily.
4.	Food Hedonic Acceptability	Daily.
5.	Tasic Completion Checklist	Daily.

11.3 SIMULATOR UTILITIES

The data management system outlined in Section 11.2 will monitor utilities. These utilities consist of power, heat transfer fluid (hot and cold), and vacuum levels.

Power measurements will be recorded automatically on magnetic tape and/or by the computer for all power supplied. As a backup to automatic recording, watt-hour meters will provide visual display of cumulative usage.

Heat transfer fluid flow to the chamber will be determined from flow meters installed in both the hot and cold supply lines outside the test chamber. The supply line flow meters will provide visual readout in addition to being recorded automatically. Recorded data will be used in determining the thermal balance and for verification that internal turbine flow meters on each subsystem are calibrated accurately.

Annulus vacuum is visually displayed and recorded by a strip-chart recorder. The recorder is utilized continuously throughout the run.

11.4 MAN/SYSTEMS

Instrumentation and data collection for man/systems include audio, visual, and psychomotor testing equipment. The audio-visual equipment will be used primarily to monitor crew activities and provide recreational inputs. The use of the psychomotor test equipment is described in Section 8. The computer will also be a part of the man/systems instrumentation and data collection equipment, in addition to serving as transmission device for engineering and medical data. In the man/systems capacity the computer link will be used to record questionnaire responses concerning food, sleep, and habitability.

11.5 BIOMEDICAL

Instrumentation and data collection for biomedical purposes will consist of an onboard medical laboratory facility, an analog measurement unit, and a physiological display unit. The onboard medical laboratory consists of equipment designed for blood sampling, analysis and storage; urine measurement, sampling, analysis and storage; and microbiological sampling analysis and storage. The data collected by the crew using the onboard medical laboratory will be transmitted to the medical monitor outside.

Biomedical instrumentation exterior to the chamber consists of the analog measurement and physiological display control which will be used for physiological data recording and display. These consoles will receive record, and display parameters such as oral temperature and various plumonary functions.

11.6 MISSION GRAPHIC DISPLAYS

Mission graphic displays will be available for orientation of visitors, consultants, and test personnel. These shall include charts posted and maintained near the test control area. These charts are:

1. Life Support Systems Operational Status-Daily-line status of LSS units and experiments.
2. Major Units of Life Support System-Block diagram of LSS operation.
3. Atmosphere values each 4 hours, for total pressure, PO_2, PCO_2, temperature, dew point, relative humidity, PCO and hydrocarbons.
4. Performance Values-Daily mass balance presenting pertinent crew and LSS values.
5. Water Management System - Status of potable water recovery system including current potable water certification information.
6. Biomedical Crew Status Trends-Weekly pertinent crew psychological data.
7. Crew-General crew information.

11.7 TEST LOGS

Each member of the staff shall maintain a separate log:

1. Test Conductor's Log
2. Medical Monitor's Log
3. Communication Monitor's Log
4. Engineering Monitor's Log
5. Electrical/Mechanical Technician's Log

It will be the responsibility of each member of the staff to maintain the log providing an entry for each shift during manned testing. Each member of the staff must obtain the signature, shift, and date of his relief before leaving the staff control area at the end of his shift. All pertinent data including data acquisition reference and abnormal conditions will be logged.

The crew shall maintain a Crew Log requiring daily inputs pertinent to their operation.

Section 12

PRETEST PROCEDURES

This section provides for the checkout, adjustment, Operational Readiness Inspection and NASA review of the completely integrated simulator supporting equipment, LSS, and procedures. For this phase of the program all systems, equipment, and instrumentation must be in a manned-test mode. Test logs must be maintained as defined in Section 11.6.

12.1 OPERATIONAL CHECKOUT

This initial operational checkout is conducted to provide the necessary information for certification of all systems, equipment and procedures for manned testing. The instructions are to be repeated as required to satisfy the Operational Readiness Inspection for manned testing.

12.1.1 Simulator/Facility Pretest Inspection

Perform the facility pretest inspection and certification per instructions in the Facilities Operating Manual (see Section 4.6). A copy of the facility pretest inspection procedure is included in Appendix A.

12.1.2 LSS Pretest Inspection

Perform the LSS pretest inspection and certification in accordance with instructions to be developed and included the Life Support Systems Operating and Checkout Manual (see Section 515). A copy of this pretest inspection procedure is to be included when available as Appendix C of this test plan.

12.1.3 Operational Countdown Sequence

The countdown sequence noted below is to be performed in accordance with the instructions contained in the Facilities Operating Manual (see Section 4.6). A copy of the countdown sequence is included as Appendix B of this test plan.

Perform the countdown sequence of Appendix B with the following variation: During the initial pumpdown per for above procedure, reduce the pressure level in the chamber to a minimal pressure consistent with the capacity of the vacuum pumping systems [approximately 2.0 kN/m^2 (15 Torr)] and hold for a minimum of 30 minutes. Then, pressurize the chamber to the levels defined in Section 2.2, using gaseoud nitrogen and oxygen. Do not perform the steps providing for ingress of the crew. All items not checked as N/A or GO must receive the approval of the Engineering Director before continuing.

12.1.4 Emergency Fire Abort Test

Deactivate the emergency water spray system. Initiate the emergency fire abort described in Section 3.6.4.3 The time required to equalize internal and external ambient pressure from receipt of the emergency abort alarms to the point at which the outer door is actually opened will be determined and reported as part of Section 12.5. Perform a visual inspection of the internal equipment for any discrepancies and log any action taken.

12.2 OPERATIONAL READINESS INSPECTION (ORI)

At this phase of the program and with completion of systems sea level operational checkouts, the test contractor's ORIC will complete its recommendations for manned rating of the test chamber, LSS, supporting equipment, facilities and procedures as described in Section 1.4. ORI approval must be obtained before continuing with Section 12.

12.3 MANNED CHECKOUT

Repeat Sections 12.1.1 and 12.1.2 Perform the facilities countdown procedure of Appendix B.

For this manned checkout test an assigned checkout crew will be used in place of the regular crew. This checkout crew will include 2 to 5 persons, each of whom has the following qualifications:

1. Volunteer for the assigned task and be aware that he has the right to withdraw at any time.
2. Demonstrated knowledge of emergency equipment and procedures associated with the test chamber and facility.
3. The technical background and capability for performing the assigned tasks.
4. An employe of the test contractor.
5. Certification by the Test Medical Director for participation in the checkout test.

The appointment as checkout test crewman will be approved by the Program Manager.

The checkout crew will perform, as a minimum, the following tasks:

1. Audio and visual communication system checkout.
2. Life support units adjustment and operating checkout.
3. Noise level measurements in the crew and equipment compartment.
4. Passout cycle.

Checkout of external systems and procedures will consist of, as a minimum, the following:

1. Trace contaminant analysis.
2. Complete LSS instrumentation data cycle.
3. Communication system audio and visual checkout including recording cycle.

Following crew egress, the test chamber may then be returned to normal sea level pressure and supporting facility items may be shut down at the direction of the Test Engineering Director, following the preflight checklist (Appendix B) in reverse order.

If necessary, the manned checkout test will be repeated in order to obtain verification of proper operation of all systems and procedures that will be used during subsequent manned test.

12.4 NASA OPERATIONAL READINESS REVIEW

Prepare a meeting agenda for the NASA Operational Readiness Review (ORR) Committee and transmit it to the Committee Chairman at NASA-LaRC. This agenda will cover all aspects of operational safety and test readiness and will consist of:

1. The results of Section 12.2, Operational Readiness Inspection.
2. Safety and emergency procedures to be used in the manned test program.
3. Demonstration of compliance with all facets of the test plan.
4. Verification of test readiness status of the simulator, LSS, procedures, support equipment, instrumentation, crew systems, spare parts and expendable provisions.
5. Confirmation of the readiness of the crew, including results of physiological and psychological examinations, and a description of all training received with corresponding aptitudes and attitudes.
6. Confirmation of the readiness of the operating staff and support personnel, including a discussion of training received and assurance of competency of all operational and emergency procedures.

Two weeks after submittal of the agenda to NASA and 2 weeks before the scheduled start of the 100-hour manned test, the test contractor will schedule the NASA Test Readiness Review meeting at the contractor's plant. At this meeting, he will present the agenda and provide a briefing on all procedures and actions taken with respect to manned test readiness. At this time, the test plan and procedure

will be presented to NASA for approval as described in Section 1.5. After the review, the test contractor will prepare and submit to NASA-LaRC a letter report including a list of action items generated with correction action taken. With the completion of Sections 12.4, and the resultant review and disposition of action items, certification and authorization for the 100-hour manned test will be given by the ORR Committee.

12.5 PRETEST PROCEDURE REPORT

Prepare an informal report on Section 12 with the content based on test readiness verification of all systems. The report will also contain a summary of required changes to the program documentation based on the results of Section 12.

Section 13

100-HOUR MANNED CHECKOUT TEST

The successful completion of the 100-hour manned checkout test, described in this section, will provide operationally tested facilities, procedures and personnel to support and man the extended duration test and will verify the total advanced subsystem and experiment readiness. At the conclusion of this test series all results are to be evaluated and any required changes incorporated into the test plan, procedures, and equipment before beginning the extended manned test. Test logs will be maintained as defined in Section 11.6.

13.1 SUBSYSTEM OPERATIONAL CONFIGURATION

A detailed description of the LSS, including advanced subsystems, is presented in Section 5, Life Support System, of this document. Prior to the final meeting of the Operation Readiness Review Committee preceding the 100-hour manned test (Section 12.4) an outline will be provided defining the operational status of the advanced subsystem and baseline units for the checkout test. This outline will be incorporated at this point in the Test Plan and Procedure by appropriate Change Notice procedure as outlined in Section 1.5.

13.2 PRETEST PREPARATION

This section describes the steps to prepare all systems, equipment, and facilities for the operational countdown and start of manned testing.

Perform a walk-through inspection of the simulator and test control area by the Program Manager. Test Conductor on duty, Engineering Director, Medical Director, Crew Integration Director, Quality Assurance Representative, NASA Contract Technical Representative, and Safety Officer. This inspection is the final visual

inspection to determine readiness of all aspects of the manned test defined in this document. Included in this inspection will be a check on the current Test Plan and Procedure, Facility Operating Manual and LSS Operating Manual located in the Test Conductor's area and the posting of the required Safety Rules and Staff Member Operating Procedures. The Test Conductor is to document this event in his log and obtain the identification and signatures of the members of the inspection team.

13.2.1 LSS Pretest Inspection

Perform the LSS pretest inspection and certification in accordance with instructions to be developed and included in the LSS Operating and Checkout Manual (see Section 5.5). A copy of the LSS pretest inspection is to be included when available in Appendix C of this test plan.

13.2.2 Simulator/Facilities Pretest Inspection

Perform the facility pretest inspection and certification per instructions in the Facilities Operating Manual (see Section 4.6). A copy of the facility pretest inspection procedure is included as Appendix A of this test plan.

13.2.3 Special Procedures

Prior to entering the chamber, the crew is to undergo a pretest biomedical examination in accordance with Section 9 and psychological examination in accordance with Section 8.

Before sealing the chamber, samples for the following chemical and microbiological analyses will be taken.

Chemical Analysis

1. Trace contaminants as required (see Section 6.2.2).
2. Water analysis as required (see Section 6.2.3).

Microbiological Analysis (Section 9.1.4)

1. Nasopharyngeal Samples
2. Potable Water Samples

13.3 TEST PROCEDURE

Perform the Facility Pretest Countdown sequence of Appendix B and the Life Support System Countdown Sequence of Appendix D.

During the third day and fifth day of the checkout test, the crew will take samples for the following analyses:

Chemical Analysis

1. Trace contaminants as required (see Section 6.2.2).
2. Water analysis as required (see Section 6.2.3).

Microbiological Analysis (Section 9.2.2)

1. Nasopharyngeal Samples
2. Potable Water Samples

The test will be terminated by egress of the crew. The simulator may then be returned to sea level pressure and supporting facility equipment may be shutdown at the direction of the Test Engineering Director, following the Pretest Checklist (Appendix B) in reverse order.

13.4 POST-TEST

The post-test procedures defined below represent minimum requirements and may be expanded at the direction of the Program Manager.

13.4.1 Simulator/LSS

Complete the chemical and microbiological analysis from the above samples.

13.4.2 Crew/Staff

The crew will be subjected to a post-test biomedical examination in accordance with Section 9 and a psychological examination in accordance with Section 8.

A staff and crew oral debriefing will be conducted with a written summary including staff/crew recommendations.

13.4.3 100-Hour Checkout Test Report

An informal test report will be drafted defining:

1. A list of items requiring action before beginning the test.
2. A list of recommended test procedure/manual changes.
3. An analysis and display of pertinent test data.
4. Statements on the medical, man/systems, microbiological and engineering results of the test.
5. A program staff/crew debriefing report

This report is to be in an informal outline format.

Section 14

EXTENDED MANNED TEST

This test plan and procedure, at this point in the program, has provided for operational testing of facilities, systems, procedures, and screening and training of personnel to support and man the extended manned test described in this section. The test requirements in this document meet the mission objectives with emphasis on mission realism consistent with a manned earth-orbiting space station.

14.1 NASA TEST READINESS REVIEW

The NASA Operational Readiness Review Committee will review the results of the 100-hour checkout test, as indicated by the Test Report (Section 13.4.3) and such on-the-spot observations and investigations as they shall consider necessary. They shall be assisted in this review by the Operational Readiness Inspection Committee and members of the test program staff. On the basis of this review they shall provide a verification of readiness for the extended manned test, contingent upon the performance of such preparatory tasks as they shall consider necessary to ensure the successful completion of the test and accomplishment of program objectives.

Test readiness verification in accordance with the requirements of this section must be completed before commencing the extended test run.

14.2 PRETEST PREPARATION

This section describes the steps necessary to prepare all systems, equipment, and facilities for the operational countdown and start of manned testing.

Conduct an all-systems checkout utilizing program technical personnel in place of the crew. This checkout is to determine the test readiness of the LSS and supporting equipment to be used in the test.

Perform a walk-through inspection of the simulator and test control area by the Program Manager, Test Conductor on duty, Engineering Director, Medical Director, Man/Systems Director, Quality Assurance Representative, NASA Contract Technical Representative, and Safety Officer. This inspection is the final visual inspection to determine readiness of all aspects of the manned test defined in this document. Included in this inspection will be a check on the current Test Plan and Procedure, Facility Operating Manual and LSS Operating Manual located in the Test Conductor's area and the posting of the required Safety Rules and Staff Member Operating Procedures. The Test Conductor is to document this event in his log and obtain the identification and signatures of the members of the inspection team.

14.2.1 LSS Pretest Inspection

Perform the LSS pretest inspection and certification in accordance with instructions in the LSS Operating and Checkout Manual (See Section 5.5). A copy of the LSS pretest inspection is included as Appendix C of this test plan.

14.2.2 Simulator/Facilities Pretest Inspection

Perform the Simulator/Facility Pretest Inspection and certification per instructions in the Facilities Operating Manual (see Section 4.6). A copy of the Facility Pretest Inspection is included as Appendix A of this test plan.

14.2.3 Facilities Countdown

Complete the **Facilities Countdown Checklist of Appendix B.** Completion of this checklist provides for the test environment, ingress of the crew and start of the test. This checklist is to be completed before continuing with the next section.

14.2.4 LSS Countdown

Complete the LSS Countdown Sequence Checklist of Appendix D. This checklist documents the sequential startup of the LSS.

14.2.5 Crew Preparation

Additional crew preparation after the final crew selection is to consist of the following, but not necessarily in the order listed:

Biomedical (see Section 9 for procedures)

1. Microbial baseline
2. Exercise tolerance and pulmonary function test
3. Total body water and plasma volume baselines
4. Baseline clinical EEG
5. Pretest briefing
6. Pre-entry physical status, blood and urine studies

Crew Integration (see Section 8 for procedures)

1. Baseline performance on all perceptual motor testing equipment
2. Psychodiagnostics review
3. Cohesion training
4. Sociometrics
5. Rules of cabin living
6. LSS maintenance training
7. Pretest briefing

Engineering

1. LSS unit operation
2. Data management
3. Pretest briefing

In addition to the above, conduct a crew/staff briefing consisting of, as a minimum:

1. Review of test documentation
2. Staff/crew protocol
3. Staff/crew data management interface
4. Emergency procedures

14.3 EXTENDED MANNED TEST

The manned test begins with the ingress of the crew in accordance with Section 14.2.3.

The procedures defined in this Test Plan and Procedure describe the operations, responsibilities, and duties of the personnel and equipment involved in the extended manned test. In order to assure that current documentation is being used, the Master Test Plan and Procedure is the only test plan approved for use by the Operating Staff.

A detailed description of the LSS, including advanced subsystems, is provided in Section 5, Life Support System. Listed below is an outline of this LSS defining the manned test planned on-line status of the advanced subsystem units and baseline units:

(NOTE: To be defined prior to the final Operational Readiness Review Committee Meeting [Section 14.1].)

14.4 POST-TEST PROCEDURE

After egress, and at the direction of the Program Manager, the test chamber will be returned to atmospheric conditions and all systems placed in a dormant

standby mode until all post-test procedures have been completed and data have been reviewed by the technology directors, the Medical Director, the Program Manager, and the NASA Technical Representative.

The crew post-test schedule of events is shown in Table 14-1.

A NASA/test contractor Oral Debriefing will be held at NASA-LaRC within 60 days of test completion.

TABLE 14-1

POST-TEST CREW ACTIVITIES SCHEDULE

DAY	TIME	TASK
0	(Test Completion Day)	
	0600 -	Egress
	0630 - 0640	Total body water
	0645 -	Blood samples
	0750 - 0815	Shower
	0815 - 0845	Plasma volume
	0845 - 0930	Breakfast - crewmen
	0930 - 0945	Body water samples
	1100 - 1130	Press interview
	1130 - 1145	Body water samples
	1145 - 1245	Luncheon
	1300 - 1700	K^{40} Body counts (Addenda) (UCLA)
	AM	Microbiology (hardware only - non crew)
	PM	Photography (hardware only - non crew)
+ 1	0830 - 0845	Spirometry
	0845 - 0915	Perceptual motor testers
	0930 - 1205	Crew/staff debriefing
	1215 - 1330	Luncheon
	1330 - 1600	Behavioral debriefing (NIPA and MA)
+ 3	0900 - 1130	Exercise (treadmill)
+ 4	0800 - 0830	Blood samples
	0830 - 9000	Microbiology
	0915 - 0945	Perceptual motor testers
	1015 - 1030	Blood sample
	1330 - 1600	Psychodiagnostics (2 men)

TABLE 14-1 (Continued)

DAY	TIME	TASK
+ 5		
	0800 -	Start urine collection
+ 6		
	0900 - 1200	Visual tests
	1215 - 1300	Luncheon
	1330 - 1600	Psychodiagnostics (2 men)
		Turn in urine sample
+18		
	0800 - 0830	Blood samples
	0830 - 0900	Microbiology
	0900 - 1030	Final exercise (ergometer)
+25		
	0800 - 0830	Blood samples
+60		
+61		Post-test debriefing, Langley, Va.
+88		
	0800 - 0830	Blood samples

Page Intentionally Left Blank

Section 15

FINAL TEST REPORT

The Final Report on the Operational Manned Test of a Regenerative Life Support System shall consist of four sections as described below. Section 11 describes the instrumentation and data acquisition equipment and defines the recorded data to be used in the final report.

15.1 SUMMARY

A summary section shall provide a resume of the salient features of the test program, including pre- and post-test activities.

1. Definition of the test objectives.
2. The evolution of the total system aspect.
3. Operation of the life support system including summary mass and thermal balances.
4. The relation and effect of the total system supporting functions.
5. Evaluation of psychological and physiological effects of the test crew.
6. Evaluation of the ability of the crew to perform useful tasks including operation, maintenance and repair of the life support and mission-related experiments.

15.2 LIFE SUPPORT SYSTEM

This section of the final report shall include:

1. A summary analysis of the overall LSS operation and data.
2. Detail tables, graphs, and pictures defining LSS unit performance and operation.
3. Analysis of repair, maintenance, and reliability data.
4. Results and summary of chemical analysis including the method of contaminantion control and measurements.

5. Review and evaluation of the use of expendables including data on mass balance.

6. Thermal balance and power consumption data.

7. Recommendations for future unit, subsystem, and system design.

15.3 CREW INTEGRATION

A detailed analysis shall be provided of the man/system aspects of the test plan and procedure with emphasis on crew performance and the effectiveness of their selection, testing, and training. Recommendations for future manned tests shall also be included.

15.4 BIOMEDICINE

Results of the biomedical effort and their analysis, including physiological and microbiological analyses. Evaluation of the effectiveness of the biomedical program and recommendations for future manned tests shall be made.

REFERENCES

1 Man-Rating Requirements (Human Factors) LaRC Management Manual Instruction 1710.3. November 17, 1969.

2 Final Test Plan and Procedure - Operational Ninety-Day Manned Test of a Regenerative Life Support System. MDAC G2282 (NASA CR-111882), May 1971.

3 Nonmetallic Materials Design Guidelines and Test Data Handbook, National Aeronautics and Space Administration, MSC-02681, Revision A, dated January 15, 1971 (or latest revision).

4 Procedures and Requirements for the Flammability and Offgassing Evaluation of Manned Spacecraft Nonmetallic Materials, National Aeronautics and Space Administration, MSC-D-NA-0002 dated July 1968.

5 Atmospheric Contaminants in Spacecraft - Report of the Panel on Air Standards for Manned Space Flights - June 1968.

6 Water Quality Standards for the Long Duration Manned Space Missions. Report of the Ad Hoc Committee of the Space Science Board, National Academy of Sciences, September 1967.

7 Standard Methods for the Examination of Water and Waste Water, 12th Edition 1965.

Appendix A

FACILITY OPERATING MANUAL PREFLIGHT CHECKLIST

Item		Reference* Section	Date	Time	Facility Operator
1	Cooling Water System	8.2.1			
2	440 Volts Power Supply System	2.3			
3	Hot Coolanol System	4.1.1			
4	Cold Coolanol System	4.2.1			
5	110 Volts Power Supply System	2.2			
6	28 VDC Power Supply System	2.4.1			
7	Test Conductor's Console Power	2.4.1			
8	Communications System	3.			
9	Pneumatics System	8.1			
10	Instrumentation & Data Systems	10.			
11	400 Cycle Power Supply System	2.1.1			
12	Oxygen Supply System	6.1.1			
13	Nitrogen Supply System	6.2.1			
14	Waste Management Vacuum System	7.4.2.1			
15	Main Vacuum System Pumps (Stokes Pumps and Gast Pump)	7.1.2			
16	Personnel Safety Equipment				
	A. Air Packs	13.1.3			
	B. Miscellaneous Rescue Equipment	13.5			
17	Water Spray System Arming	12.2 & 12.3			

* NOTE: From the Facility Operating Manual

Appendix B

FACILITY OPERATING MANUAL PREFLIGHT CHECKLIST

Item		Reference* Section	Date	Time	Operator
1	Add N_2 to desired pressure level (if required)	6.2			
2	Operate in "continuous operation of altitude" mode for duration of test	7.2.4.1			
3	Lock in crew members	7.2.5.1			
5	At the completion of planned testing, lock out crew members	7.2.5.2			
5	Return SSS to ambient pressure	7.2.4.2			
6	Shut down supporting facility items by following the pre-flight check list in reverse	11.1			

* NOTE: From the Facility Operating Manual

Appendix C

PREFLIGHT SEQUENCE AND PROCEDURES

A.1 LSS PREFLIGHT SEQUENCE

This appendix, when completed, will outline the procedures which must be accomplished to verify the operational readiness of the Life Support System prior to actual start-up of the Life Support Units. It will be similar in content to Appendix C of Reference 1-2 and will be developed by the test contractor during the initial phase of test planning.

Each unit procedure must be verified and signed off by the cognizant principal engineer before the unit can be started.

Appendix D

LSS COUNTDOWN SEQUENCE

B.1 LSS COUNTDOWN SEQUENCE

The Life Support System Countdown Sequence Checklist must be developed by the test contractor and inserted at this location. It indicates the initial startup sequence of the life support subsystems. This checklist must be signed off by the Life Support Units Principal Engineers, the Test Conductor, and the Program Manager to complete the LSS start-up.

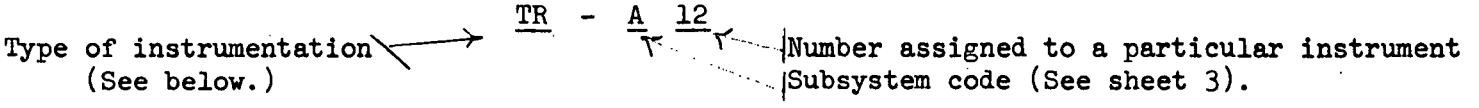
Appendix E

INSTRUMENTATION LIST AND DATA MANAGEMENT PLAN

The following presents a preliminary list of instrumentation and indication of type of display and usage. This is included in the Test Plan and Procedure for reference and to indicate to the test contractor and others the type of information required on subsystem instrumentation for purposes of preliminary coordination. This list includes the baseline subsystems and a limited number of advanced subsystems where some definition is available, and is based upon subsystems described in Section 5 and instrumentation schematics in Section 11.

The coded identification number for the instruments consists of a two-part alpha-numeric designation. The first portion of the designation identifies the type of instrumentation. The second portion identifies a particular instrument and the subsystem to which it belongs.

Example:



The instrument numbers are assigned sequentially for each type of instrumentation within a given subsystem. See following code:

Type of instrumentation - The suffix "I" is generally used for instruments which provide instantaneous visual readouts only. The suffix "R" signifies that the data is being recorded or, as in the case of watt-hour and elapsed time meters, an accumulated total value of a parameter is available for visual readout.

Code	Type of Instrumentation	Code	Type of Instrumentation
AI	Ammeter Recorder	OD	Ozone Detector
CTR	Event Counter	PdI	Differential Pressure Indicator
DWI	Dew Point Indicator	PdR	Differential Pressure Recorder
DWR	Dew Point Recorder	PI	Pressure Indicator
ETR	Elapsed Time Recorder	PR	Pressure Recorder
FE	Flow Sensor	TCS	Temperature Controller Sensor
FET	Flow Totalizer (Gas)	TI	Temperature Indicator
FI	Flow Indicator	TE	Temperature Sensor
FMT	Flow Totalizer (Liquid)	TR	Temperature Recorder
FR	Flow Recorder	VI	Voltmeter
GSR	Gas Sample Recorder (MSA gas monitor)	WHR	Watt Hour Recorder
		WI	Watt Indicator
HD	Hydrogen Detector	WIR	Watt Recorder
LQ	Liquid Quantity Recorder	WTM	Wet Test Meter
LW	Load Cells (Cold Trap Wt.)		
MSR	Mass Spectrometer Sensor		

Subsystems Code

Code	Subsystem	Code	Subsystem
A	Carbon Dioxide Removal	L	Zero-Gravity Whole Body Shower
B	Water Management	M	Vapor Compression Water Reclamation
C	Thermal/Humidity Control	N	Electrolytic Pretreatment
D	Two-Gas Atmosphere Control	O	
E	Toxin - Sabatier Control	P	Hydrogen Depolarized Concentrator
F	Electrolysis Unit	Q	
G	Simulator Support	R	Solid Polymer Electrolyte
H	Waste Management	S	Reverse Osmosis

Instrumentation readout locations are coded as follows:

1 Unit or component mounted
2 CRT display for operating staff
3 CRT display for simulator crew
4 Print-out
5 Backup engineering console (LSM)
6 Gas analysis console
7 Simulator peripheral area
8 Crew life support monitor (CLSM)

Information utilization from the instrumentation consists of the categories indicated below:

I Thermal balance calculation
II Water mass balance calculation
III Gas mass balance calculation
IV Unit status check (monitor and/or alarm)
V Fault isolation
VI Automatic control feedback parameter

CODE: A UNIT: CO_2 CONCENTRATOR

ITEM	DESCRIPTION	I.D. NO.	SENSOR LOCATION	READ-OUT LOCATION	UTILIZATION
1-A	Thermocouple	TR-A1	Silica gel bed no. 1,	2, 3, 4, 5, 8	I
			gas inlet		
2-A	Thermocouple	TR-A2	Silica gel bed no. 1,	2, 3, 4, 5, 8	I
			gas outlet		
3-A	Thermocouple	TR-A3	Silica gel bed no. 1,	2, 3, 4, 5	I
			bed middle		
4-A	Thermocouple	TR-A4	Silica gel bed no. 2,	2, 3, 4, 5, 8	I
			gas inlet		
5-A	Thermocouple	TR-A5	Silica gel bed no. 2,	2, 3, 4, 5, 8	I
			gas outlet		
6-A	Thermocouple	TR-A6	Silica gel bed no. 2,	2, 3, 4, 5	I
			bed middle		
7-A	Thermocouple	TR-A7	HX gas inlet	2, 3, 4, 5	I
8-A	Thermocouple	TR-A8	HX gas outlet	2, 3, 4, 5, 8	I
9-A	Thermocouple	TR-A9	Desorbing silica gel	2, 3, 4, 5, 8	I, IV
			cond., gas inlet		
10-A	Thermocouple	TR-A10	Desorbing silica gel	2, 3, 4, 5, 8	I, IV
			cond., gas outlet		
11-A	Thermocouple	TR-A11	Molecular sieve bed no.	2, 3, 4, 5, 8	I
			1, gas inlet		
12-A	Thermocouple	TR-A12	Molecular sieve bed no.	2, 3, 4, 5, 8	I
			1, gas outlet		
13-A	Thermocouple	TR-A13	Molecular sieve bed no.	2, 3, 4, 5	I
			1, bed front middle		
14-A	Thermocouple	TR-A14	Molecular sieve bed no.	2, 3, 4, 5, 8	I
			2, gas inlet		
15-A	Thermocouple	TR-A15	Molecular sieve bed no.	2, 3, 4, 5, 8	I
			2, gas outlet		

CODE: A UNIT: CO_2 CONCENTRATOR

ITEM	DESCRIPTION	I.D. NO.	SENSOR LOCATION	READ-OUT LOCATION	UTILIZATION
16-A	Thermocouple	TR-A16	Molecular sieve bed no.	2, 3, 4, 5	I
			2, bed front middle		
17-A	Thermocouple	TR-A17	CO_2 accumulator	2, 3, 4, 5	III
18-A	Thermocouple	TR-A18	Silica gel bed no. 1,	2, 3, 4, 5	I
			fluid inlet		
19-A	Thermocouple	TR-A19	Silica gel bed no. 1,	2, 3, 4, 5	I
			fluid outlet		
20-A	Thermocouple	TR-A20	Silica gel bed no. 2,	2, 3, 4, 5	I
			fluid inlet		
21-A	Thermocouple	TR-A21	Silica gel bed no. 2,	2, 3, 4, 5	I
			fluid outlet		
22-A	Thermocouple	TR-A22	Molecular sieve bed no.	2, 3, 4, 5	I
			1, fluid inlet		
23-A	Thermocouple	TR-A23	Molecular sieve bed no.	2, 3, 4, 5	I
			1, fluid outlet		
24-A	Thermocouple	TR-A24	Molecular sieve bed no.	2, 3, 4, 5	I
			2, fluid inlet		
25-A	Thermocouple	TR-A25	Molecular sieve bed no.	2, 3, 4, 5	I
			2, fluid outlet		
26-A	Thermocouple	TR-A26	HX, coolant inlet	2, 3, 4, 5	I
27-A	Thermocouple	TR-A27	HX, coolant outlet	2, 3, 4, 5	I
28-A	Thermocouple	TR-A28	Silica gel condensor,	2, 3, 4, 5	I
			coolant outlet		

CODE: A UNIT: CO_2 CONCENTRATOR

ITEM	DESCRIPTION	I.D. NO.	SENSOR LOCATION	READ-OUT LOCATION	UTILIZATION
29-A	Pressure	PI-A1	Blower outlet	1	IV
30-A	Differential	PDI-A2	Differential gas	1	IV
	pressure		(blower inlet, outlet)		
31-A		PDI-A3	Differential gas	1	IV
			(silica gel bed no. 1)		
32-A		PDI-A4	Differential gas	1	IV
			(silica gel bed no. 2)		
33-A		PDI-A5	Differential gas (HX)	1	IV
34-A		PDI-A6	Differential gas (molec-	1	IV
			ular sieve bed no. 1)		
35-A	↓	PDI-A7	Differential gas (molec-	1	IV
			ular sieve bed 2)		
36-A	Pressure	PI-A8	Upstream of 3-way valve	1	IV
			which selects desorption		
			vacuum source		
37-A	Pressure	PR-A9	Upstream of 3-way valve	2, 3, 4	IV
			which selects desorption		
			vacuum source		
38-A	Pressure	PI-A10	Vacuum pump outlet	1	IV
39-A	Pressure	PR-A11	CO_2 Accumulator	2, 3, 4	III, IV
40-A	Pressure	PI-A12	Space vacuum pump inlet	1	IV
41-A	Differential	PDI-A13	Differential gas (con-		
	pressure		densor separator)	1	IV
42-A	↓	PDI-A14	Differential liquid		
			(silica gel bed no. 1)	1	IV
43-A	↓	PDI-A15	Differential liquid	1	IV
			(silica gel bed 2)		

CODE: A UNIT: CO_2 CONCENTRATOR

ITEM	DESCRIPTION	I.D. NO.	SENSOR LOCATION	READ-OUT LOCATION	UTILIZATION
44-A	Differential	PDI-A16	Differential liquid	1	IV
	pressure		(molecular sieve bed 1)		
45-A		PDI-A17	Differential liquid	1	IV
			(molecular sieve bed 2)		
46-A		PDI-A18	Differential liquid (HX)	1	IV
47-A		PDI-A19	Differential liquid	1	IV
			(condensor-separator)		
48-A	Gas flow	FR-A1	Gas flow to adsorbing	2, 3, 4, 5	IV
			silica gel bed		
49-A	Gas flow	FR-A2	Gas flow from adsorbing	2, 3, 4, 5	IV
			molecular sieve bed		
50-A	Gas flow	FR-A3	Gas flow to desorbing	2, 3, 4, 5	IV
			silica gel bed		
51-A	Gas flow	FR-A4	CO_2 flow to accumulator	2, 3, 4, 5	III, IV
52-A	Fluid flow	FR-A5	Silica gel - cold fluid	2, 3, 4, 5	I
			inlet		
53-A	Fluid flow	FR-A6	Molecular sieve - cold	2, 3, 4, 5	I
			fluid inlet		

CODE: A UNIT: CO_2 CONCENTRATOR

ITEM	DESCRIPTION	I.D. NO.	SENSOR LOCATION	READ-OUT LOCATION	UTILIZATION
54-A	Fluid flow	FR-A7	HX and condensor - cold fluid inlet	2, 3, 4, 5	I
55-A	Fluid flow	FR-A8	Silica gel - hot fluid inlet	2, 3, 4, 5	I
56-A	Fluid flow	FR-A9	Molecular sieve - hot fluid inlet	2, 3, 4, 5	I
57-A	Gas flow totalizer	FET-A6	Gas flow to adsorbing silica gel bed	8	III
58-A	Gas flow totalizer	FET-A7	Gas flow from adsorbing molecular	8	III
			sieve bed		
59-A	Gas flow totalizer	FET-A8	Gas flow to desorbing silica gel bed	8	III
60-A	Gas flow totalizer	FET-A9	Gas flow to CO_2 accumulator	8	III
61-A	Gas flow totalizer	WTM-A1	CO_2 sample port	5	III
62-A	Gas sample	GSR-A1	Gas outlet at condensor-separator	2, 3, 4, 5, 6	IV
			discharge		
63-A	Gas sample	GSR-A2	Gas discharge at adsorbing M.S. outlet	2, 3, 4, 5, 6	IV
64-A	Gas sample	GSR-A3	HX inlet	2, 3, 4, 5, 6	IV

CODE: A UNIT: CO_2 CONCENTRATOR

ITEM	DESCRIPTION	I.D.NO.	SENSOR LOCATION	READ-OUT LOCATION	UTILIZATION
65-A	Dew Point	DWR-A1	Adsorbing silica gel bed gas outlet	2, 3, 4, 5	IV
66-A	Dew Point	DWR-A2	Desorbing silica gel bed gas outlet	2, 3, 4, 5	IV
67-A	Dew Point	DWR-A3	Adsorbing molecular sieve bed outlet	2, 3, 4, 5	IV
68-A	Power	WI-A1	Blower	1	I, IV
69-A	Power	WHR-A2	Vacuum pump motors	7	I
70-A	Power	WHR-A3	Controls	7	I
71-A	Operation time	ETR-A1	Vacuum pump	1	I, IV
72-A	Operation time	ETR-A2	Condensate pumped to holding tank	1	II

CODE: B UNIT: WATER MANAGEMENT

ITEM	DESCRIPTION	I.D.NO.	SENSOR LOCATION	READ-OUT LOCATION	UTILIZATION
1-B	Thermocouple	TR-B1	Wash water tank no. 1	2, 3, 4, 5	IV
2-B	Thermocouple	TR-B2	Wash water tank no. 2	2, 3, 4, 5	IV
3-B	Thermocouple	TR-B3	Holding (potable) tank no. 1	2, 3, 4, 5	IV
4-B	Thermocouple	TR-B4	Holding (potable) tank no. 2	2, 3, 4, 5	IV
5-B	Thermocouple	TR-B5	Potable tank no. 3	2, 3, 4, 5	IV
6-B	Thermocouple	TR-B6	Potable tank no. 4	2, 3, 4, 5	IV
7-B	Thermocouple	TR-B7	Potable tank no. 5	2, 3, 4, 5	IV
8-B	Thermocouple	TR-B8	Potable tank no. 6	2, 3, 4, 5	IV
9-B	Thermocouple	TR-B9	Wick evaporator - inlet	2, 3, 4, 5	IV
10-B	Thermocouple	TR-B10	Wick evaporator - outlet	2, 3, 4, 5	IV
12-B	Thermocouple	TR-B12	Condenser/separator outlet	2, 3, 4, 5	I
13-B	Thermocouple	TR-B13	Coolant - inlet to condenser	2, 3, 4, 5	I
14-B	Thermocouple	TR-B14	Coolant - outlet from condenser	2, 3, 4, 5	I
15-B	Thermocouple	TR-B15	Raw urine accumulator tank	2, 3, 4, 5	I
16-B	Thermocouple	TR-B16	Wash water HX - coolant inlet	2, 3, 4, 5	I
17-B	Thermocouples	TR-B17	Wash water HX - coolant outlet	2, 3, 4, 5	I
18-B	Differential pressure	PDI-B1	Wash water 30 micron filter	1	IV
19-B	Differential pressure	PDI-B2	Wash water 3 micron filter	1	IV
20-B	Differential pressure	PDI-B3	Wash water 1 micron filter	1	IV
21-B	Differential pressure	PDI-B4	Wash water charcoal filter 1 - inlet	1	IV
22-B	Differential pressure	PDI-B5	Course filter	1	IV
23-B	Pressure	PI-B6	N_2 pressure in wash tank 1	1	IV

CODE: B UNIT: WATER MANAGEMENT

ITEM	DESCRIPTION	I.D.NO.	SENSOR LOCATION	READ-OUT LOCATION	UTILIZATION
24-B	Pressure	PI-B7	N_2 pressure in wash tank 2	1	IV
25-B	Pressure	PI-B8	N_2 pressure in raw urine accumulator	1	IV
			tank		
26-B		PI-B9	N_2 pressure in flush water storage	1	IV
27-B		PI-B10	N_2 pressure in electrolysate accumula-	1	IV
			tor tank		
28-B		PI-B11	N_2 pressure in holding tanks 1 and 2	1	IV
29-B		PI-B12	N_2 pressure in potable tanks 3, 4, 5	1	IV
			and 6		
30-B		PI-B13	Blower outlet	1	IV
31-B	Differential pressure	PDI-B14	Wick evaporator	1	IV
32-B		PDR-B15	Flow tube	1	I
33-B		PDI-B16	Condenser/separator fluid	1	IV
34-B	Flow	FI-B1	Potable H_2O filtration rate	1	IV
35-B	Flow	FI-B2	Wash H_2O filtration rate	1	IV
36-B	Flow totalizer	FMT-B3	Wash H_2O flow totalizer	1	II
37-B	Flow	FR-B3	Coolant flow to wick evaporator cond.	2, 3, 4	I
38-B	Gas analysis	GSR-B1	Wick evaporator outlet	2, 3, 4, 6	IV
39-B	Gas analysis	GSR-B2	Wick evaporator inlet	2, 3, 4, 6	IV

CODE: B UNIT: WATER MANAGEMENT

ITEM	DESCRIPTION	I.D.NO.	SENSOR LOCATION	READ-OUT LOCATION	UTILIZATION
40-B	Dew point	DWR-B1	Wick evaporator inlet	2, 3, 4, 6	II
41-B	Dew point	DWR-B2	Wick evaporator outlet	2, 3, 4, 6	II, IV
43-B	Power	WI-B1	Wick evaporator blower	1	IV
44-B	↓	WI-B2	Wick evaporator heater	1	IV
45-B		WIR-B3	Wick evaporator blower	2, 3, 4	I
48-B	Power	WHR-B6	Holding (potable) tank 1	7	I
49-B	|	WHR-B7	Holding (potable) tank 2	7	I
50-B	|	WHR-B8	Potable tank 3	7	I
51-B	|	WHR-B9	Potable tank 4	7	I
52-B	|	WHR-B10	Potable tank 5	7	I
53-B	|	WHR-B11	Potable tank 6	7	I
54-B	|	WHR-B12	Wash water tank 1	7	I
55-B	|	WHR-B13	Wash water tank 2	7	I
56-B	↓	WHR-B14	Sink pump	7	IV
57-B	Power	WIR-B15	Wick evaporator heater	2, 3, 4	IV

CODE: B UNIT: WATER MANAGEMENT

ITEM	DESCRIPTION	I.D.NO.	SENSOR LOCATION	READ-OUT LOCATION	UTILIZATION
59-B	Operating time	ETR-B1	Wick evaporator heater	1	I
60-B	↓	ETR-B2	Wick evaporator blower	1	IV
61-B		ETR-B3	Potable water pumped from wick evap.	8	II
62-B		ETR-B4	Urine pump	1	II
63-B	Liquid quantity	LQ-B1	Holding (potable) tank 1	2, 3, 4	II
64-B	↓	LQ-B2	Holding (potable) tank 2	2, 3, 4	II
65-B		LQ-B3	Potable tank 3	2, 3, 4	II
66-B		LQ-B4	Potable tank 4	2, 3, 4	II
67-B		LQ-B5	Potable tank 5	2, 3, 4	II
68-B		LQ-B6	Potable tank 6	2, 3, 4	II
69-B		LQ-B7	Wash water tank 1	2, 3, 4	II
70-B	↓	LQ-B8	Wash water tank 2	2, 3, 4	II
71-B	Liquid feed counter	CTR-B1	Potable water transferred to wash	8	II
			system		
72-B	Liquid feed counter	CTR-B2	Potable water consumed by crew	3	II

CODE: C UNIT: THERMAL/HUMIDITY CONTROL

ITEM	DESCRIPTION	I.D.NO.	SENSOR LOCATION	READ-OUT LOCATION	UTILIZATION
1-C	Thermocouple	TR-D1	Thermal control HX gas inlet - left	2, 3, 4, 5	I
2-C		TR-D2	Thermal control HX gas inlet - right	2, 3, 4, 5	I
3-C		TR-D3	Thermal control HX gas outlet - left	2, 3, 4, 5	I
4-C		TR-D4	Thermal control HX gas outlet - right	2, 3, 4, 5	I
5-C		TR-D5	Return air	2, 3, 4, 5	I, IV
6-C		TR-D6	Humidity HX - inlet	2, 3, 4, 5	I
7-C		TR-D7	Humidity HX - outlet	2, 3, 4, 5	I, IV
8-C		TR-D8	Bunk area	2, 3, 4, 5	I
9-C		TR-D9	Equipment area	2, 3, 4, 5	I
10-C		TR-D10	Living area	2, 3, 4, 5	I
11-C		TR-D11	Thermal control HX - coolant inlet	2, 3, 4, 5	I, IV
12-C		TR-D12	Thermal control HX - coolant outlet	2, 3, 4, 5	I
13-C		TR-D13	Humidity HX - coolant inlet	2, 3, 4, 5	I, IV
14-C	↓	TR-D14	Humidity control HX - coolant outlet	2, 3, 4, 5	I
15-C	Pressure	PI-D1	Cabin absolute pressure	8	IV
16-C	Differential pressure	PDI-D2	Thermal control venturi	1	IV
17-C	Differential pressure	PDR-D3	Thermal control venturi	4	I
18-C	Pressure	PR-D4	Cabin total pressure	2, 3, 4	IV
19-C	Differential pressure	PDI-D5	Humidity control HX ΔP	1	IV
20-C	Differential pressure	PDI-D6	Thermal control filter ΔP	1	IV

CODE: C UNIT: THERMAL/HUMIDITY CONTROL

ITEM	DESCRIPTION	I.D.NO.	SENSOR LOCATION	READ-OUT LOCATION	UTILIZATION
21-C	Flow	FR-D1	Thermal control - HX inlet	2, 3, 4	I
22-C	Flow	FR-D2	Humidity control - HX inlet	2, 3, 4	I
24-C	Gas analysis	GSR-D1	Thermal control - HX outlet	2, 3, 4, 5, 6	IV
25-C	Gas analysis	GSR-D2	Humidity control cond.-separator outlet	2, 3, 4, 5, 6	IV
27-C	Dew Point	DWR-D1	Humidity control - HX inlet	2, 3, 4, 5	I, II
28-C	Dew Point	DWR-D2	Humidity control cond.-separator	2, 3, 4, 5	I, II
29-C	Dew Point	DWR-D3	Thermal control filter inlet	2, 3, 4, 5	IV
30-C	Power	WI-D1	Thermal/humidity unit blower 1	1	IV
31-C	↓	WI-D2	Thermal/humidity unit blower 2	1	IV
32-C	↓	WIR-D3	Thermal/humidity unit blower 1 and 2	4	I
33-C	↓	WHR-D4	Thermal/humidity unit pump and controls	7	I

CODE: C UNIT: THERMAL/HUMIDITY CONTROL

ITEM	DESCRIPTION	I.D.NO.	SENSOR LOCATION	READ-OUT LOCATION	UTILIZATION
34-C	Operating time	ETR-D5	Humidity control condensate pump	8	11

CODE: D UNIT: MASS SPECTROMETER/TWO-GAS

ITEM	DESCRIPTION	I.D.NO.	SENSOR LOCATION	READ-OUT LOCATION	UTILIZATION
1-D	Pressure	PI-E1	O_2 line	1	IV
2-D		PI-E2	N_2 line	1	IV
3-D		PR-E3	O_2 partial (backup)	1, 2, 3, 4	IV
4-D		PR-E4	Total pressure	2, 3, 4	IV
5-D		PR-E5	O_2 partial (mass spect)	1, 2, 3, 4	III, IV
6-D		PR-E6	N_2 partial (mass spect)	1, 2, 3, 4	III, IV
7-D		PR-E7	CO_2 partial (mass spect)	1, 2, 3, 4	III, IV
8-D		PR-E8	H_2O partial (mass spect)	1, 2, 3, 4	III, IV
9-D		PR-E9	O_2 accumulator	1, 2, 3, 4	III
10-D		PI-E10	O_2 storage tank	1	IV
11-D	↓	PR-E11	O_2 storage tank	1, 2, 3, 4	III, IV
12-D	Flow	FR-E1	O_2 two-gas supply	4	IV
15-D	Totalizing flow	FET-E1	O_2 two-gas supply	1	III

CODE: D UNIT: MASS SPECTROMETER/TWO-GAS

ITEM	DESCRIPTION	I.D.NO.	SENSOR LOCATION	READ-OUT LOCATION	UTILIZATION
17-D	Totalizing counters	CTR-E1	O_2 - two-gas supply	1	III
18-D	Totalizing counters	CTR-E2	N_2 - two-gas supply	1	III
20-D	Gas analysis	GSR-E1	O_2 accumulator	1	IV

CODE: E UNIT: TOXIN/SABATIER

ITEM	DESCRIPTION	I.D.NO.	SENSOR LOCATION	READ-OUT LOCATION	UTILIZATION
1-E	Thermocouple	TR-F1	Economizer HX - cold side inlet	2, 3, 4, 5	I
2-E		TR-F2	Economizer HX - cold side outlet	2, 3, 4, 5	I
3-E		TR-F3	Economizer HX - hot side inlet	2, 3, 4, 5	I
4-E		TR-F4	Economizer HX - hot side outlet	2, 3, 4, 5	I
5-E		TR-F5	Reactor bed rear	2, 3, 4, 5	IV
6-E		TR-F6	Reactor bed middle	2, 3, 4, 5	IV
7-E		TR-F7	Reactor bed front	2, 3, 4, 5	IV
8-E		TR-F8	Coolant - cond. supply	2, 3, 4, 5	I
9-E		TR-F9	Coolant - cond. return	2, 3, 4, 5	I
10-E		TI-F10	Sabatier catalyst bed bottom	5	IV
11-E		TR-F11	CH_4 outlet at condenser outlet	2, 3, 4, 5	I
12-E	Temperature indicator/	TCS-F1	Reactor temperature controller	1	IV
	controller				
13-E		TCS-F2	Catalytic bed controller	1	IV
15-E	Pressure	PI-F1	Sabatier reactor - H_2 supply	1	IV
16-E		PI-F2	Sabatier reactor - CO_2 supply	1	IV
17-E		PI-F3	Sabatier reactor - mixed gas inlet	1	IV
18-E		PR-F4	Sabatier reactor - mixed gas inlet	2, 3, 4	IV

CODE: E UNIT: TOXIN/SABATIER

ITEM	DESCRIPTION	I.D.NO.	SENSOR LOCATION	READ-OUT LOCATION	UTILIZATION
19-E	Pressure	PI-F5	CH_4 pressure - orifice outlet	2, 3, 4	IV
20-E		PR-F6	H_2 accumulator	2, 3, 4	III
22-E	Differential pressure	PDI-F6	Economizer D. P.	1	IV
23-E	Fluid flow	FR-F1	Coolant to condenser	2, 3, 4, 5	I
24-E	Fluid flow totalizer	FMT-F1	Condenser - condensate	8	II
25-E	Gas flow totalizer	WTM-F1	CH_4 overboard dump	7	III

CODE: E UNIT: TOXIN/SABATIER

ITEM	DESCRIPTION	I.D.NO.	SENSOR LOCATION	READ-OUT LOCATION	UTILIZATION
27-E	Gas analysis	GSR-F1	Economizer hot side outlet flow	2, 3, 4, 5, 6	IV
28-E	Gas analysis	GSR-F2	Sabatier case	2, 3, 4, 5, 6	IV
29-E	Operating time	ETR-F1	Heater operating time	1	I

CODE: F UNIT: ELECTROLYSIS

ITEM	DESCRIPTION	I.D.NO.	SENSOR LOCATION	READ-OUT LOCATION	UTILIZATION
1-F	Thermocouple	TR-G1	Module 1 - front plate	2, 3, 4, 5	IV
2-F		TR-G2	Module 1 - mid-front	2, 3, 4, 5	
3-F		TR-G3	Module 1 - mid-rear		
4-F		TR-G4	Module 1 - rear plate		
5-F		TR-G5	Module 2 - front plate		
6-F		TR-G6	Module 2 - mid-front		
7-F		TR-G7	Module 2 - mid-rear		
8-F		TR-G8	Module 2 - rear plate		
9-F		TR-G9	Module 3 - front plate		
10-F		TR-G10	Module 3 - mid-front		
11-F		TR-G11	Module 3 - mid-rear		
12-F		TR-G12	Module 3 - rear plate		
13-F		TR-G13	Supply electrolyte		I
14-F		TR-G14	Return electrolyte		I
15-F		TR-G15	O_2 gas - condenser inlet		I
16-F		TR-G16	O_2 gas - condenser outlet		I
17-F		TR-G17	Cold plate temperature		IV
18-F		TR-G18	Separator temperature		IV
19-F		TR-G19	Cooling water supply		I
20-F		TR-G20	Cooling water return		I

CODE: F UNIT: ELECTROLYSIS

ITEM	DESCRIPTION	I.D.NO.	SENSOR LOCATION	READ-OUT LOCATION	UTILIZATION
23-F	Pressure	PI-G1	Electrolyte	1	IV
24-F		PI-G2	Hydrogen gas	1	
25-F		PI-G3	Oxygen gas	1	
26-F		PR-G1	Electrolyte	2, 3, 4	IV
27-F		PR-G2	Hydrogen gas	2, 3, 4	IV
28-F		PR-G3	Oxygen gas	2, 3, 4	IV
29-F	Differential pressure	PdI-G4	Manifold DP	1	IV
30-F		PdR-G5		2, 3, 4	IV
31-F	Flows	FR-G1	Total unit coolant	2, 3, 4, 5	I
32-F		FR-G2	Cold plate	2, 3, 4, 5	I
33-F		FR-G3	Electrolyte	2, 3, 4, 5	IV
34-F		FR-G4	H_2 flow to accumulator	2, 3, 4	III

CODE: F UNIT: ELECTROLYSIS

ITEM	DESCRIPTION	I.D.NO.	SENSOR LOCATION	READ-OUT LOCATION	UTILIZATION
36-F	Voltage	VR-G1	Module 1 - cell 1	2, 3, 4	IV
37-F		VR-G2	2		
38-F		VR-G3	3		
39-F		VR-G4	4		
40-F		VR-G5	5		
41-F		VR-G6	6		
42-F		VR-G7	7		
43-F		VR-G8	8		
44-F		VR-G9	9		
45-F		VR-G10	10		
46-F		VR-G11	11		
47-F		VR-G12	12		
48-F		VR-G13	13		
49-F		VR-G14	14		
50-F		VR-G15	15		
51-F		VR-G16	Module 2 - cell 1		
52-F		VR-G17	2		
53-F		VR-G18	3		
54-F		VR-G19	4		
55-F		VR-G20	5		
56-F		VR-G21	6		
57-F		VR-G22	7		
58-F		VR-G23	8		
59-G		VR-G24	9		
60-G		VR-G25	10		
61-F		VR-G26	11		
62-F		VR-G27	12		
63-F		VR-G28	13		
64-F	↓	VR-G29	14	↓	↓

CODE: F UNIT: ELECTROLYSIS

ITEM	DESCRIPTION	I.D.NO.	SENSOR LOCATION	READ-OUT LOCATION	UTILIZATION
65-F	Voltage	VR-G30	Module 2 - cell 15	2, 3, 4	IV
66-F		VR-G31	Module 3 - cell 1		
67-F		VR-G32	2		
68-F		VR-G33	3		
69-F		VR-G34	4		
70-F		VR-G35	5		
71-F		VR-G36	6		
72-F		VR-G37	7		
73-F		VR-G38	8		
74-F		VR-G39	9		
75-F		VR-G40	10		
76-F		VR-G41	11		
77-F		VR-G42	12		
78-F		VR-G43	13		
79-F		VR-G44	14		
80-F	↓	VR-G45	↓ 15	↓	↓
81-F	Voltage	VR-G46	Module 1 - total volts	2, 3, 4	IV
82-F		VR-G47	Module 2 - total volts		
83-F		VR-G48	Module 3 - total volts		
84-F	↓	VR-G49	Total volts (unit)	↓	↓

CODE: F UNIT: ELECTROLYSIS

ITEM	DESCRIPTION	I.D.NO.	SENSOR LOCATION	READ-OUT LOCATION	UTILIZATION
86-F	Current	AR-G1	Module 1	2, 3, 4	IV
87-F	↓	AR-G2	Module 2	↓	↓
88-F		AR-G3	Module 3		
89-F		AR-G4	Total current (unit)		
91-F	Operating time	ETR-G1	Electrolysis unit operating time	1	IV

CODE: G UNIT: SIMULATOR SUPPORT

ITEM	DESCRIPTION	I.D.NO.	SENSOR LOCATION	READ-OUT LOCATION	UTILIZATION
1-G	Temperature	TI-H1	Coolanol reservoir - coolant pump discharge	1	IV
2-G		TR-H2	Cold coolanol - chamber supply	2, 3, 4, 5	I
3-G		TR-H3	Cold coolanol - chamber return		
4-G		TR-H4	Hot coolanol - chamber supply		
5-G		TR-H5	Hot coolanol - chamber return		
6-G		TI-H6	Hot coolanol reservoir	1	
7-G		TR-H7	Chilled water - chamber supply	2, 3, 4, 5	I
8-G		TR-H8	Chilled water - chamber return	2, 3, 4, 5	I
10-G	Temperature	TR-H10	Simulator bunk area	2, 3, 4, 5	I
11-G		TR-H11	Simulator equipment area	2, 3, 4, 5	I
12-G		TR-H12	Simulator living area	2, 3, 4, 5	I
18-G	Pressure	PI-H1	Hot fluid - reservoir pump discharge	1	IV
19-G		PI-H2	Cold coolanol - reservoir pump discharge		
20-G		PI-H3	Hot fluid reservoir - N_2 purge		
21-G		PI-H4	Cold coolanol reservoir - N_2 purge		
22-G		PI-H5	Chilled water expansion tank - N_2 purge		
23-G	Pressure	PI-H6	Cabin total pressure	1	IV
24-G		PR-H7	Cabin total pressure	2, 3, 4	IV

CODE: G UNIT: SIMULATOR SUPPORT

ITEM	DESCRIPTION	I.D.NO.	SENSOR LOCATION	READ-OUT LOCATION	UTILIZATION
27-G	Fluid flow	FR-H1	Cold coolanol - simulator supply	2, 3, 4, 5	I
28-G	↓	FR-H2	Hot coolanol - simulator supply	2, 3, 4, 5	↓
29-G		FR-H3	Chilled water - simulator supply	2, 3, 4, 5	
31-G	Gas analysis	GAC-H1	Equipment area	2, 3, 4, 5, 6	IV
32-G	↓	GAC-H2	Waste management area	↓	↓
33-G		GAC-H3	Food preparation area		
34-G		GAC-H4	Bunk area		
35-G		GAC-H5	Food storage cabinet		
38-G	Dew Point	DWR-H1	Equipment area - wick evaporator	2, 3, 4, 5	IV
40-G	Hydrogen detectors	HD-D1	Thermal/humidity control unit inlet	5	IV
41-G	↓	HD-D2	Sabatier unit purge gas outlet	↓	↓
42-G		HD-D3	Electrolysis area		
43-G		HD-D4	Gas analysis console		

CODE: G UNIT: SIMULATOR SUPPORT

ITEM	DESCRIPTION	I.D.NO.	SENSOR LOCATION	READ-OUT LOCATION	UTILIZATION
44-G	Power	WHR-H1	Chamber lights	7	I
45-G	↓	WHR-H2	Miscellaneous equipment	7	I
46-G	Power	WIR-H3	28 volt power to SSS	2, 3, 4	I
47-G	↓	WIR-H4	115 volt power to SSS chamber lights	2, 3, 4	I
48-G		WIR-H5	400 Hz power	↓	↓
49-G		WIR-H6	115 - power to chamber lights		
50-G		WIR-H7	Power to sink pump and heated tanks		
51-G		WIR-H8	Power to heated tanks		
52-G		WIR-H9	Power to heated tanks and mole. sieve		
53-G	↓	WIR-H10	Power to heated tanks & thermal control		
59-G	Operating time	ETR-H1	Cold coolanol pump (1)	1	IV
60-G		ETR-H2	Cold coolanol pump (2)	↓	↓
61-G		ETR-H3	Hot coolanol pump		
62-G		ETR-H4	Chilled water pump		
63-G		ETR-H5	Dunham Bush chiller		
64-G		ETR-H6	York chiller circuit 1		
65-G	↓	ETR-H7	York chiller circuit 2	↓	↓

CODE: H UNIT: WASTE MANAGEMENT

ITEM	DESCRIPTION	I.D.NO.	SENSOR LOCATION	READ-OUT LOCATION	UTILIZATIO.
1-H	Operating Time	ETR-J1	Slinger motor	1	IV
2-H	↓	ETR-J2	Urine accumulator pump	1	II
3-H	Weight	LW-J1	Cold trap no. 1	2, 3, 4	II
4-H	↓	LW-J2	Cold trap no. 2	2, 3, 4	II
7-H	Temperature	TCS-J1	Cold trap temperature	1	IV
8-H		TI-J2	Cold trap no. 1	1	IV
9-H	↓	TI-J3	Cold trap no. 2	1	IV
11-H	Pressure	PI-J1	Heating and cooling media to traps	1	IV
12-H	↓	PI-J2	Cold trap vacuum	1	IV

CODE: L (Preliminary) UNIT: ZERO-GRAVITY WHOLE BODY SHOWER

ITEM	DESCRIPTION	I.D. NO.	SENSOR LOCATION	READ-OUT LOCATION	UTILIZATION
1-L	Thermocouple	TR-L1	Blower outlet	4	IV
2-L	↓	TR-L2	Heater inlet	4	I
3-L	↓	TR-L3	Heater outlet	2, 3	I
4-L	↓	TR-L4	Shower stall gas exit	4	IV
8-L	Differential Pressure	PDR-L1	Blower	2, 3, 4	IV
9-L	↓ ↓	PDR-L2	Heater	4	IV
10-L	↓ ↓	PDR-L3	Liquid gas separator	4	IV
11-L	Pressure	PR-L4	Vacuum pump line	2, 3, 4	IV
14-L	Flow Totalizer	FMT-L1	Water flow to stall	1	II
15-L	↓	FMT-L2	Waste H_2O out	1	II
18-L	Dew Point	DWR-L1	Heater outlet	4	IV
19-L	↓ ↓	DWR-L2	Gas side return	2, 3, 4	IV
22-L	Power	WIR-L1	Blower	2, 3, 4	I
23-L	↓	WIR-L2	Heater	2, 3, 4	I
24-L	Operating Time	ETR-L1	Heater	1	I
25-L	↓ ↓	ETR-L2	Blower	1	I

CODE: M

UNIT: VAPOR COMPRESSION WATER RECLAMATION

ITEM	DESCRIPTION	I.D. NO.	SENSOR LOCATION	READ-OUT LOCATION	UTILIZATION
			INSTRUMENTATION TBD		

CODE: N UNIT: ELECTROLYTIC PRETREATMENT

ITEM	DESCRIPTION	I.D. NO.	SENSOR LOCATION	READ-OUT LOCATION	UTILIZATION
1-N	Thermocouple	TR-N1	Raw urine accumulator tank	4	IV
6-N	Pressure	PR-N1	Transfer pump outlet	2, 3, 4	IV
7-N	↓	PR-N2	Raw urine accumulator tank	4	IV
8-N	↓	PR-N3	Electrolysate accumulator tank	4	IV
9-N	↓	PR-N4	Flush water storage	4	IV
12-N	Power	WI-N1	Transfer pump	1	IV
13-N	↓	WI-N2	Circulating & trans. pump	1	IV
14-N	↓	WIR-N3	Electrolytic cell	2, 3, 4	I
20-N	Operating Time	ETR-N1	Transfer pump	1	II
21-N	↓ ↓	ETR-N2	Electrolytic cell	1	I
22-N	↓ ↓	ETR-N3	Circulating and transfer pump	1	IV
28-N	Liquid Quantity	LQ-N1	Raw urine accumulator tank	2, 3, 4	II
29-N	↓ ↓	LQ-N2	Electrolysate accumulator tank	2, 3, 4	II
		Additional instrumentation TBD.			

CODE: P UNIT: HYDROGEN DEPOLARIZED CONCENTRATOR

ITEM	DESCRIPTION	I.D. NO.	SENSOR LOCATION	READ-OUT LOCATION	UTILIZATION
1-P	Thermocouple	TR-P1	Heat exchanger inlet	2, 3, 4	I
2-P	↓	TR-P2	Heat exchanger outlet	2, 3, 4	I
8-P	Pressure	PR-P1	O_2 supply	2, 4	IV
9-P	↓	PR-P2	H_2 supply	2, 4	IV
10-P	↓	PR-P3	CO_2 - H_2 accumulator	2, 4	III
15-P	Flow	FR-P1	Cabin air	2, 3, 4	IV
16-P	↓	FR-P2	H_2 supply	2, 4	III
17-P	↓	FR-P3	CO_2 - H_2 accumulator	2, 4	III
18-P	↓	FR-P4	Heat exchanger coolant flow	2, 4	I
19-P	Flow Totalizer	FET-P1	Cabin air	5	IV
20-P	↓	FET-P2	H_2 accumulator supply	5	III
24-P	Gas Analysis	GSR-P1	CO_2 - H_2 analyzer	4, 6	III
28-P	Power	WIR-P1	Blower power	2, 4	I
29-P	↓	WIR-P2	Cell power generated	2, 4	I
	(Preliminary)	Additional instrumentation TBD.			

CODE: R

UNIT: SOLID POLYMER ELECTROLYTE

ITEM	DESCRIPTION	I.D. NO.	SENSOR LOCATION	READ-OUT LOCATION	UTILIZATION
			INCOMPLETE INSTRUMENTATION TBD		
12-R	Flow	FR-R1	H_2 supply	2, 3, 4	IV
13-R	↓	FR-R2	O_2 supply	2, 3, 4	IV
16-R	Flow Totalizer	FET-R1	H_2 supply totalizer	5	III
17-R	↓ ↓	FET-R2	O_2 supply totalizer	5	III
20-R	Counter	CTR-R3	H_2O supply	8	II

CODE: S UNIT: REVERSE OSMOSIS

ITEM	DESCRIPTION	I.D. NO.	SENSOR LOCATION	READ-OUT LOCATION	UTILIZATION
			INCOMPLETE INSTRUMENTATION TBD		
15-S	Operating Time	ETR-S1	Pressure pump	1	I, IV
16-S	↓ ↓	ETR-S2	Recirculating pump	1	I, IV
20-S	Power	WIR-S1	Pressure pump	2, 3, 4	I, IV
21-S	↓	WIR-S2	Recirculation pump	2, 3, 4	I, IV

APPENDIX F

DESIGN REQUIREMENTS SPECIFICATION

The following Design Requirements Specification presents the requirement for material and equipment furnished for integration into the manned test chamber. This specification is MDAC Drawing 1T33501, revised July 30, 1971, and is included in the Test Plan and Procedure as preliminary information to subsystem suppliers and for reference to the NASA and the selected test contractor. Although much of the information presented in this document is specifically related to MDAC procedures and documentation, it is expected that the selected test contractor will be able to use much of the detail information presented, substituting where necessary his equivalent material.

DESIGN REQUIREMENTS SPECIFICATION

1T33501

1. SCOPE

This document shall be used as a guide for the design, drawing preparation and procurement requirements to insure test success and crew safety as well as a guide for the Quality Control (QC) and Operational Readiness Inspection (ORI) standards for the test chamber and manned test installations. McDonnell Douglas Astronautics Company (MDAC) fabricated installations shall be controlled by all the requirements of this document. Government furnished equipment (GFE) shall be controlled by all the requirements of this document with the exception of the documentation requirements as noted herein. Vendor furnished equipment (VFE) shall be controlled by the Q.C., material and integration requirements specified in the appropriate sections of this document.

2. APPLICABLE DOCUMENTS

2.1	NASA CR-111882.	Test Plan and Procedure. May 1971 (or latest revision).
2.2	NASA CR-891.	Engineering Criteria for Spacecraft Cabin Atmosphere Selection. September 1967 (particularly Section 8)
2.3	MSC-02681	Nonmetallic Materials Design Guidelines and Test Data Handbook. Revision A, 1-15-71 (or latest revision).
2.4	MSC-D-NA-0002	Procedures and Requirements for the Flammability and Outgassing Evaluation of Manned Spacecraft Nonmetallic materials. July 1968.
2.5	LaRCI 1710.1	Human Factors Research Classification and Safety Review. LaRC Management Manual Instruction. 11-17-69.
2.6	LaRCI 1710.2	Operational Readiness Inspections of Human Factors Research Test Facilities and Equipment. LaRC Management Manual Instruction. 11-17-69.
2.7	LaRCI 1710.3	Man-Rating Requirements (Human Factors). LaRC Management Manual Instruction. 11-17-69.
2.8	MSFC STD-267A	Human Engineering Design Criteria Standard
2.9	DPS 02052	Identification of Fluid Lines

2.10 DPS 10001	Tubing Assembly - Flared Type
2.11 DPS 10002	Tubing Assembly and Fitting Installation - Flared Type
2.12 DPS 41370	Vapor Degreasing
2.13 DPS 44250	Anti-Seize Lubricants for Mating Parts
2.14 DPS 52050	Electrical Bonding
2.15 DPS 54000 Series	Electrical Wiring Fabrication and Installation (as applicable).
2.16 MIL-STD-454B	Standard General Requirements for Electronic Equipment Requirement 1, Safety (Personnel Hazard).
2.17 CP5.061C M	Man/Manned Testing Policy. 8-6-69 (or latest revision).
2.18 M5.057-C	Safety Manual
2.19 MDAC Paper No. 3344	Accelerated Procedure for Determination of Gas-Off Products from Space Cabin Materials. April 1965.

3. GENERAL REQUIREMENTS

3.1 Safety

NASA LaRC Management Manual Instructions 1710.1, 1710.2 and 1710.3 shall be considered the governing documents which establish the minimum safety requirements for the design and construction of manned test installations.

3.2 Environment

Equipment which will be installed within the test chamber shall be capable of operating in the chamber environment per NASA CR-111882, Section 2.2

3.3 Vendor Furnished Equipment

All VFE (e.g, refrigerator, freezer, washer, dryer, TV camera, onboard laboratory equipment, etc.) shall not be required to be fabricated to all the requirements of this document. All VFE will be inspected by QC for hazardous conditions, such as improper grounding, or hazardous components, such as mercury switches. Inspection items will be reviewed by the Program Engineering Director for final disposition.

3.4 Commonality

Commonality between components in all systems must be considered during the design phase in order to reduce the spares inventory, reduce the on-board maintenance problems and achieve quantity price breaks. Major items are blowers, electric motors, solenoid valves, relays, manual valves, pumps, etc.

3.5 Human Engineering

Accessibility and simplicity must be a prime consideration in all designs. Equipment controls, displays and labeling requirements must be coordinated with the Program Crew Integration Director. MSFC STD-267A shall be used as a human engineering guideline.

3.6 Interior Color Scheme

The interior color scheme must be coordinated with the Program Crew Integration Director. Consider the use of anodized aluminum partitions rather than painted.

3.7 Acoustic

Acoustic considerations must be incorporated in the complete design. All units must be sound engineered to meet the noise level requirements of NCA-60. Over silencing in the high frequencies shall be limited to 5db below the NCA-60 level in order to prevent a "hole" from occurring in the ear hearing range.

3.8 Illumination

Interior illumination requirements must be considered in the complete design. Daylight flourescent tubes are recommended to provide improved television picture quality. This requirement must be coordinated with the Program Crew Integration Director.

3.9 Electro-Magnetic Interference (EMI)

Potential EMI problems must be considered during the design and installation of equipment. Power, signal and instrumentation wiring shall be routed separately and use separate connectors.

3.10 Facility Grounding

The facility ground shall be checked and must not exceed 4 ohms. All internal electrical equipment shall be grounded to the chamber structure with a maximum resistance of one ohm.

3.11 Fail Safe Design

Facilities and life support equipment must be designed such that test personnel shall not be subjected to a test environment wherein a credible single point failure will result in injury. In addition, the design must be such that unenergized solenoids will fail in the safe position. Any exceptions must be approved by the Program Engineering Director.

3.12 Contamination Control

The Contamination Control Facility will be activated after the chamber is painted and prior to installation of major equipment items. This facility maintains a filtered positive pressure in the chamber and, prior to installation, all equipment will be wiped clean and vacuumed. The procedures used with this facility operating shall be per NASA CR-111882, Section 3.5. Prior to installation in the chamber, all openings in equipment, such as fluid and gas lines, shall be sealed with appropriate closures.

4. MATERIAL REQUIREMENTS

4.1 Nonmetallic Materials

All nonmetallic materials used in the chamber shall be identified and classified according to the categories defined in MSC-02681 which are based on material usage. This identification and classification shall be the responsibility of the equipment, subsystem, or system supplier. All materials shall have been tested to the requirements contained in

MSC-D-NA-0002 unless data is provided which satisfactorily establishes compliance with the requirements. Such evidence of compliance shall exist with or be submitted to MDAC Test Program Management.

If material satisfies more stringent requirements than required for the category in which it is being used, it may be used in this category without retesting. "No ignition" is considered more stringent than "self-extinguishing," which is considered more stringent than a combustion rate. High pressure oxygen is considered more stringent than low pressure oxygen. Ignition on the bottom of the specimen is considered more stringent than ignition at the top. Applicable atmosphere shall be specified in NASA CR-111882.

Material which is not listed in MSC-02681 may be used if additional testing per Section 4.1.2 of this document establishes acceptability for the chamber environment. Materials which have been tested and approved for the environment are lised in Table 1.

4.1.1 Nonmetallic Material Control

Nonmetallic materials listed in MSC-02681 are acceptable for use in the chamber environment if the outgassing test results are less than 25.0 micrograms of CO per gram of material and 100.0 micrograms of total organics (TO) per gram of material. All new material must be screened for outgassing and flammability characteristics and an effort must be made to eliminate combustibles such as Tygon tubing and other plastics. If an acceptable substitute cannot be obtained all combustibles shall be covered with aluminum tape or other noncombustible approved material with the exception of meter faces and similar applications where transparency is essential to the function and acceptable replacements for plastic materials cannot be provided.

TABLE 1

LIST OF NONMETALLIC MATERIALS APPROVED
FOR USE IN THE TEST ENVIRONMENT

Material	Usage
Min-K Insulation	Unlimited
S.S. Thermoflex Insulation	"
Kaowool Insulation	"
Vibrodampener*	"
RTV-1016 Sealant	"
RTV-731 Sealant	"
Silastic 651 Ducting	"
Pentone	"
Methacrylicester Paint	"
7869679 Wire	"
DPM 1833 Tefglas Tape	"
DPM 3001 Teflon Tape	"
DPM 2766 Teflon Tape	"
DPM 2918-1 Aluminum Tape	Limited
Neoprene Rubber (covered with DPM 2918-1 Tape or contained with metal flanges)	"
Duro-Dyne Flex Connector	"
Armaflex 22 (covered with DPM 2918-1 Tape)	"
PF-704 Acoustic Insulation	"
PF-339 Acoustic Insulation	"
No. 116 Volan A Fiber Glass Cloth	"
Polysulfone	"

* Identical to Dyna-Stop Coating Type CK

The supplier of GFE and VFE shall establish the necessary control to ensure that the material screening, usage and special testing requirements of this document are satisfied.

The supplier shall submit to Program Management for approval, his list of materials intended to be used. Available data from any previous material flammability or outgassing tests shall also be submitted. The list shall be reviewed by MDAC Test Program Management and each material shall be accepted, rejected or submitted for further testing.

The contractor or supplier shall maintain a list of materials used, including identification of each material, its category of usage and the weight and exposed surface area of each material used in each category. All materials shall be reported. Revisions to this list shall be reported to MDAC Program Management.

4.1.2 Special Tests of Nonmetallic Material

The materials used in any special tests to validate data submitted concerning both outgassing and flammability characteristics shall be the same as used in a production component, however, the configuration may vary and the test items need not be functional.

Special tests will be conducted by MDAC on materials for which there is no information available in the data bank. These special tests, using a procedure modified from MSC-D-NA-0002, may include both outgassing and flammability. The outgassing studies will be conducted in the manner described in MDAC Paper No. 3344. The test material of known weight and surface area will be placed in a 72-liter flask containing a gas mixture identical to the composition scheduled for use in the chamber. The test material will be exposed to 322°K (120°F) for three days. Air samples will then be withdrawn from the flask for analysis by gas chromatography, mass spectrometry and infrared spectroscopy. Identification of the outgassed materials and their quantities will permit control of the ultimate composition of the chamber air.

Burning properties will be determined by the procedure described in NASA CR-891. This consists of placing a specimen of the test material between two high voltage electrodes (15,000V, 60 ma) in a bell jar apparatus. The atmospheric composition and pressure inside the bell jar will correspond to that of the chamber. The high-voltage spark will be started and the response of the specimen will be visually observed. Time to ignition and rate of flame propagation (if any) will be measured.

MDAC has conducted a number of manned tests. As a result, MDAC has conducted a number of special tests to determine compatibility and acceptability of specific materials. The results of these tests are included in Table 2 and as such become a part of this plan, to be used with MSC-02681.

4.1.3 Deviations

Materials that do not meet the requirements of MSC-02681 may be used only upon receipt of MDAC Test Program Management approval of the request for deviation.

Requests for deviation from any of the requirements contained herein or in MSC-02681 shall be minimized by judicious selection of materials during the design phase of the equipment, subsystem or system being delivered. In the case of equipment, etc., already designed, efforts shall be expended to replace nonacceptable materials with acceptable materials from MSC-02681. When no acceptable substitute can be found, the supplier shall request a deviation from any or all of the requirements stipulated. The request for deviation shall contain complete engineering analysis and justification for the deviation.

4.2 Metallic Materials

4.2.1 Mercury

Mercury will not be allowed within the chamber at any time with the exception of that included in fluorescent tubes for illumination as specified in Section 4.3 of this document.

Table 2

MATERIALS TEST RESULTS FROM PREVIOUS MANNED TESTS

Materials	Subjective Conclusion	Outgassing Characteristic	Total Organics Outgassed ppm	Flammability Characteristic
Personal Equipment				
Mocassin, rubber soled	Rejected	Very strong outgassing		
Mocassin, leather soled	Approved	Low outgassing		
Betadine surgical scrubbing solution	Rejected	1 ml in solution with 37 ml H_2O releases 1.64 mg iodine		NA
Insulating Materials				
Polyfoam	Rejected	Strong outgassing	29.1	
Insulating Cement	Rejected	Strong outgassing	24.2	
Microfoil	Rejected	Strong outgassing	18.5	
Min-K	Approved	Low outgassing	7.6	
S.S. Thermoflex	Approved	Low outgassing	2.1	
Kaowool	Approved	Low outgassing	0.73*	Does not ignite or burn
Kaowool wetted with Coolanol-25 (5 g Kaowool, 15 drops of Coolanol)	Rejected	NA		Ignites, burns readily with high and smoking flame.
Kaowool wetted with Coolanol-25 all covered with aluminum foil; a small area of aluminum removed	Approved	NA		Area without aluminum ignites where spark hits; burning not sustained.

*This consists of acetaldehyde, propionaldehyde, ethylacetate, diethylketone, all non-toxic at these concentrations.

Table 2 (Page 2 of 3)

MATERIALS TEST RESULTS FROM PREVIOUS MANNED TESTS

Materials	Subjective Conclusion	Outgassing Characteristic	Flammability Characteristic
Nylons			
Green Nylon, Cotton, Stretch	Rejected	No outgassing	Ignites and burns readily
Natural, woven nylon	Incomplete	No outgassing	Fabric smolders, but no open flame.
Nomex	APPROVED at sea level atmosphere	No outgassing	Ignites and burns readily at 7 psia, 50% oxygen
Paints			
Polyvinyl Acetate Paint	Rejected	Very strong outgassing	
Epoxypaint	Rejected	Very strong outgassing	
Methacrylicester Paint, water based, special naval formulation	Approved	Very low outgassing	
Electric Wire			
Douglas Spec: 7869679, 22 gauge, one conductor, shielded, jacketed, all teflon	Approved	No outgassing	Exposed to 50 amps, 1.5 V; no smoking, no burning, only shrinking of jacket
Revere Corp., 20 gauge, stranded, teflon insulated, shielded, nylon jacketed; one conductor	Rejected		Exposed to 50 amps; nylon jacket smokes after 35 in., shield red after 52 in.; current went through conductor, shield
Heat Transfer Fluids			
Coolanol-25, liquid heated above 350°F (See also above under Insulation)		Immediate removal of spilled Coolanol required since it decomposes beyond 350°F; formation of CO and 2-ethylbutanol	Readily ignites; smokes and burns

Table 2 (Page 3 of 3)

MATERIALS TEST RESULTS FROM PREVIOUS MANNED TESTS

Materials	Subjective Conclusion	Outgassing Characteristic	Flammability Characteristic
Miscellaneous			
Micarta	Rejected	Strong outgassing of formaldehyde	
Vibrordampener, Korfund-dampener; water based; $CaMgSiO_3$; air dried	Approved	No outgassing	
Sealant, red; RTV-1016 sealer, General Electric; Silicone Prod. Dept.	Approved	Very little outgassing, traces of acetone, MEK	
Silicon Rubber (boots) Silastic 651; Dow Corning	Approved	Very little outgassing; total: 1.5 ppm (as carbonyl compound)	
Silicon Rubber, S-2007 Dow Corning	Rejected	Very strong outgassing of ethyl alcohol n-butyl alcohol, aldehydes	
Neoprene Rubber, black, used as gaskets, electrical cords	To be used sparingly	Strong outgassing of SO_2, CS_2, toluene, trichlorethylene	Burns readily and sustains flame, nichrome igniter
Vinylskin and leaded rubber	Rejected	Strong outgassing or organics; carbonyl compounds	Ignites readily and sustains flame, nichrome igniter
Teflon Impregnated Fiber Glass	Approved	Very low outgassing, traces of acetone, acetaldehyde	Material does not ignite, nichrome igniter
Pentone	Approved	No outgassing	NA
Duro-Dyne, Durlon flex connector	Approved	No outgassing	Burns only when ignited; does not sustain burning
Floor covering, Kochtread fiber glass plus binder	Rejected	Very strong outgassing of aldehydes, acetone, MEK, etc.	NA

4.2.2 Cadmium

Cadmium-plated components should be used sparingly. Cadmium is acceptable only in areas below 394°K (250°F) and shall not be used in potable water or food systems.

4.2.3 Copper and Brass

Copper and brass components should be used sparingly. Acceptable and restricted applications are noted in Section 4.3 of this document.

4.2.4 Aluminum

Aluminum shall be used primarily for structural and ducting applications. Other applications and restrictions are noted in Section 4.3 of this document.

4.2.5 Mild Steel

Mild steel shall be used for structural applications only. Exposed mild steel surfaces shall be protected with Methacrylicester paint or approved equivalent.

4.2.5 Stainless Steel

Stainless steel is approved for unlimited usage in the chamber.

4.3 Material Application

4.3.1 Potable and Wash Water Systems

All water systems, with the exception of the Firex water spray and chilled water systems, shall be constructed of stainless steel and teflon components. The use of copper, brass and plastics shall be restricted and must have Program Engineering Director approval.

4.3.2 Thermal Conditioning Fluid Systems

The Coolanol-35 and chilled water piping inside the chamber shall be constructed of stainless steel. The use of copper and brass shall be restricted to the outside installation and penetration fittings. Because of cost and procurement problems, large valves and components of brass and copper construction may be used inside the chamber. However, these valves must be of better quality than commercial plumbing (e.g., Crane, Lunkenheimer, etc.).

Aluminum components will not be allowed in the chilled water system. Aluminum alloy 5052 is approved for usage in the Coolanol-35 system. The use of other aluminum alloys in the Coolanol-35 system is restricted and must have program Engineering Director approval.

4.3.3 Fluorescent Light Fixtures

The use of fluorescent tubes must be minimal. All tubes must be installed in approved light fixtures and protected from damage by suitable shields.

4.3.4 Internal Wiring

All internal electrical installations shall be made with teflon-coated wire or approved equivalent. Vendor off-the-shelf components containing plastic covered wire is acceptable if the wire is enclosed in metal or other approved non-combustible material. Hermetic or metal canned relays, sealed switches, enclosed circuit breakers, and enclosed motors should be used. If sealed or enclosed components cannot be procured, the open contacts shall be enclosed in metal or other approved non-combustible material. Explosion proof equipment is not required.

4.3.5 Oxygen Systems

It shall be the responsibility of the design engineer of breathing oxygen systems to select components which are compatible with oxygen.

4.3.6 Fluid and Gas Instrumentation Lines

All fluid and gas analysis sample lines shall be constructed of stainless steel. The use of copper and brass will not be allowed in these applications. Aluminum tubing and fittings may be used in instrumentation pressure sensing lines only.

4.3.7 Flexible Fluid Connections

Flexible hoses shall be of teflon and stainless steel construction or approved equivalent. Silastic 651 boots covered with aluminum tape or other approved material will be used for all duct hose connections.

4.3.8 Vendor Furnished Equipment

Vendor furnished equipment will be evaluated for combustible material and an effort made to replace combustibles. If an acceptable substitute cannot be obtained, the quantity and location of these combustibles will be recorded on the inventory list maintained by QC. Vendor items will be inspected per Section 3.3 of this document.

All vinyl, nylon and neoprene-insulated power cords on VFE will be replaced with teflon-insulated wire when practical. If replacement is impractical, all exposed cords will be covered with teflon tubing or tape.

5. CLEANING REQUIREMENTS

5.1 Cleaning Chamber Interior

Non-ionic detergent (DPM 443-2) shall be used for general purpose cleaning in the chamber. The use of other solvents shall be restricted and must have Program Engineering Director approval.

The cleanliness requirement for the chamber interior is to have a visibly clean habitation area. Visibly clean refers to a level of cleanliness having no quantitative limits and is construed to mean the absence of foreign debris and contaminants from all accessible surfaces as determined

by the unaided eye. Surfaces cleaned to this level are visibly free of physical contaminants such as corrosion products, metal and nonmetallic chips and shavings, scale, weld slag, water oil or grease.

The interior surfaces shall be inspected and cleaned, if necessary, per the following procedure.

5.1.1 Clean surfaces by wiping with a clean cloth (DPM 3018) moistened with distilled water containing 0.1 to 0.5% by volume non-ionic detergent (DPM 443-2).

5.1.2 Rinse with distilled water.

5.1.3 Wipe dry with a clean cloth (DPM 3018) or purge dry with nitrogen.

5.2 Pre-Installation Cleaning of Equipment

5.2.1 General Cleaning Procedures

Unless specified otherwise on the Unit Drawing General Notes or in this document, all life support equipment shall be inspected and cleaned, if necessary, per the following procedure.

5.2.1.1 Remove all visual evidence of hydrocarbons, oils, greases, etc., by wiping surfaces with a clean cloth (DPM 3018) moistened with isopropyl alcohol (DPM 530). Follow by wiping with a clean, dry wiping cloth.

5.2.1.2 Clean particulate contamination from parts by air purging or vacuum cleaning.

5.2.1.3 Visually examine all surfaces for evidence of contamination and repeat 5.2.1.1 and 5.2.1.2 until all visually accessible surfaces are free of contamination.

5.2.2 Special Procedures

5.2.2.1 Gas Systems

All gas system tubing and accumulators (oxygen, nitrogen, hydrogen, methane, carbon dioxide and gas analysis) shall be cleaned, prior to installation, either by vapor degreasing per DPS 41370 or by flushing internally with a minimum of 10 volumes of isopropyl alcohol (DPM 530). If alcohol is used, dry by pruging with dry nitrogen. Absence of residual solvent will be demonstrated by chromatographic analysis of purge nitrogen sample showing less than 0.5 ppm residual solvent prior to installation of the component into the chamber.

Components installed in these systems shall be cleaned, if necessary, per Section 5.2.1 of this document.

5.2.2.2 Potable and Wash Water Systems

The water system tubing and backup water tanks shall be cleaned by vapor degreasing or flushing with isopropyl alcohol per Section 5.2.2.1 above. The zero-g water tanks will be cleaned by flushing with 10 volumes of distilled water only.

Components installed in these systems shall be cleaned, if necessary, per Section 5.2.1 of this document.

NOTE: DO NOT USE ANY DETERGENTS TO CLEAN INTERNAL AREAS OF THE WATER SYSTEMS.

5.2.2.3 Thermal Conditioning Fluid Systems

The Coolanol-35 and chilled water piping inside the chamber shall be cleaned by vapor degreasing per DPS 41370 prior to installation. Components installed in the Coolanol-35 and chilled water systems shall be cleaned, if necessary, per Section 5.2.1 of this document.

5.3 Post-Installation Checkout and Cleaning of Equipment

5.3.1 Trace Contaminant Analysis Test

The water systems (potable and wash) and gas systems (except utility nitrogen pneumatics and gas analysis sample lines) shall be tested after installation per the following procedure.

5.3.1.1 The gas accumulators (oxygen, hydrogen and carbon dioxide), the zero-g water tanks, the backup water storage tanks and associated piping will be tested for traces of cleaning solvents. This test will be accomplished by removing a gas sample from each vessel, while purging the entire system with dry nitrogen, and analyzing the gas sample for 1, 1, 1 Trichlorethane, Freon TF, Isopropyl Alcohol, Methyl Alcohol, Methylene Chloride and Perchloroethylene. Analysis shall be by gas chromatography. Trace contaminants shall not exceed 0.5 ppm.

5.3.1.2 If the trace contaminants exceed 0.5 ppm, continue to purge with dry nitrogen and sample until the test is acceptable.

5.3.2 Gas Analysis Console (GAC) Test

The GAC installation shall be tested per the following procedure.

5.3.2.1 Activate the GAC Beckman hydrocarbon analyzer (Model 109A) with the zero adjust turned to the clockwise limit and the attenuator switch in the XIO position.

5.3.2.2 Disconnect one sample line from the normal sample point and reconnect to a dry nitrogen source.

5.3.2.3 Activate the selected sample valve and the GAC compressor No. 1.

5.3.2.4 Introduce a sufficient nitrogen flow to maintain normal sea level pressure at the compressor inlet (reference gage PI-K3).

5.3.2.5 The reading on the hydrocarbon analyzer shall be less than 50% of scale. If the reading is higher, heat the sample line tubing with a heat gun until the test is acceptable.

5.3.2.6 Repeat steps 5.3.2.2 through 5.3.2.5 for each sample line.

5.3.3 Final Water System Cleaning

After testing for trace contaminants per Section 5.3.1 of this document, the potable and wash water systems will be cleaned per the following procedure.

5.3.3.1 Flush with one volume of distilled water.

5.3.3.2 Flush with one volume of distilled water containing 1% NH_3.

5.3.3.3 Flush with two volumes of distilled water.

5.3.3.4 Flush with one volume of distilled water containing 1% chlorine.

5.3.3.5 Flush with two volumes of distilled water containing 10 ppm chlorine.

The final certification of the water systems shall be per NASA CR-111882.

5.3.4 Final Gas Systems Analysis

During the all systems checkout test and prior to the 100 hrs. manned test, the gas downstream of all sorbent and catalyst beds will be tested for traces of cleaning solvents per the procedure in Section 5.3.1.1 of this document. If trace contaminants exceed 0.5 ppm, the sorbent and/or catalyst bed will be replaced with new material and retested.

6. PRESSURE REQUIREMENTS

6.1 Pressure Vessels

All pressure vessels installed in the chamber shall be designed in accordance with the ASME Unifired Pressure Vessel Code, ICC Regulations, or in accordance with good engineering practice for the pressure and service in which that are to be used.

6.2 Pressure Piping and Components

Pressure piping and components shall be designed with a minimum proof pressure of 1.5 times the maximum working pressure and burst pressure shall not be less than four times the maximum working pressure. Proof and burst testing will not be required but M5.057-C, Section 28.7, shall be used as a pressure system design guideline.

6.3 Use of Vendor Data

It shall be the responsibility of the design engineer to review vendor data for compliance of purchased parts with the requirements of Sections 6.1 and 6.2 of this document. The maximum working pressure, as stated by vendor data, shall be noted on the unit drawing for each purchased part.

6.4 GFE and VFE Data

It shall be the responsibility of each supplier of GFE and VFE to provide the maximum working pressure data to MDAC. This information will be incorporated by MDAC into the interface document per Section 7.4 of this document.

7. INTEGRATION REQUIREMENTS

7.1 Data System

Instrumentation and signal conditioning equipment shall interface with the data management system and must meet the following requirements.

7.1.1 All instrumentation, with the exception of thermocouples, shall be assembled using 2-wire plus guard shield wiring. All thermocouples shall be iron-constantan, Type J.

7.1.2 The data system capacity is a maximum of 700 analog channels with an impedance of 100 megohoms. These channel accept the following signals:

200 Channels - Each is step adjustable to accept signals of ± 10 millivolts, ± 100 milivolts, ± 1.0 volts, or ± 5.0 volts.

500 Channels - Each group of 100 channels are adjustable between ± 10 millivolts to ± 250 millivolts.

Suppliers shall obtain channel allocation from MDAC prior to selecting instrumentation.

7.1.3 It shall be the responsibility of each supplier of GFE and VFE to provide adequate monitor and alarm capabilities and instrumentation for performance measurement suitable for input to the data system described in 7.1.2. These requirements shall be coordinated with MDAC Test Program Management.

7.2 Onboard Utilities

The availability of the utilities for onboard equipment must be negotiated with each supplier of GFE and VFE. The following utilities are available.

7.2.1 Electrical Power

7.2.1.1 115 VAC, 60 Hz, 1 Phase

A total of twenty circuits are installed each with 20-amp circuit protection.

7.2.1.2 120/208 VAC 400 Hz, 3 Phase

One 50 amp circuit is provided. All onboard units must be provided with individual circuit protection.

7.2.1.3 28 VDC

Two 28 vdc circuits of 60 amps each are provided. An onboard power distribution panel is provided for more efficient distribution of the 28 vdc power. The 28 vdc power is normally utilized for low current control power only.

7.2.2 Thermal Conditioning Fluid

7.2.2.1 Chilled Water Loop

Provides chilled water at 278 ± 1.7 °K (40 ± 3°F) at a maximum pressure of 550 kN/m^2 gage (80 psig).

7.2.2.2 Coolanol-35 Loop

Provides Coolanol-35 fluid at the following conditions:

Cold - 274 to 278 °K (34 to 40°F) at a maximum pressure of 620 kN/m^2 gage (90 psig)

Hot - 422 to 436°K (300 to 325°F) at a maximum pressure of 344 kN/m^2 gage (50 psig)

7.2.3 Nitrogen Pneumatics

A gaseous nitrogen supply is provided for actuation of pneumatic controlled valves and pressurization of zero-g bladder tanks. Nitrogen is provided at a maximum pressure of 344 kN/m^2 gage (50 psig). Valves and components utilizing this pneumatic source must have provisions to vent the nitroge- overboard into the chamber annulus.

7.2.4 Space Vacuum

A simulated space vacuum is provided with a minimum pressure of 133.3 N/m^2 (1.0 mm Hg) absolute.

7.3 Installation Volume Limitations

In order to be installed in the chamber, all equipment must be capable of pasing through the airlock. The dimensions and door locations of the airlock are shown in Figure 1.

7.4 Interface Control

In order to control the interface requirements for GFE and VFE, these requirements will be negoitated and mutually agreed upon early in the design phase. An interface control document will be prepared for each GFE and VFE and submitted to the supplier for approval. After approval, this document will become a portion of the MDAC documentation and any changes must be submitted for approval through the normal release system.

8. DOCUMENTATION REQUIREMENTS

8.1 GFE Documentation

In addition to the interface control document noted in Section 7.4, the documentation for GFE equipment shall consist of a mechanical schematic, an electrical schematic, and an operating manual. These schematics shall include a list of material identifying dynamic components (e.g., valves, solenoids, pumps, etc.) and all questionable material per Section 4.1.1 of this document.

The General Notes of GFE drawings shall describe the procedures and processes utilized during fabrication. The MDAC General Notes outlined in Sections 8.3.8 and 8.3.9 of this document may be used as a design guideline. The Process Standards (DPS) and Process Materials (DPM) noted in this document (8.3.8 and 8.3.9) are MDAC internal documents and are not binding on suppliers of GFE. However, it shall be the responsibility of the supplier to submit to MDAC evidence that the procedures and processes utilized are equivalent to MDAC standards.

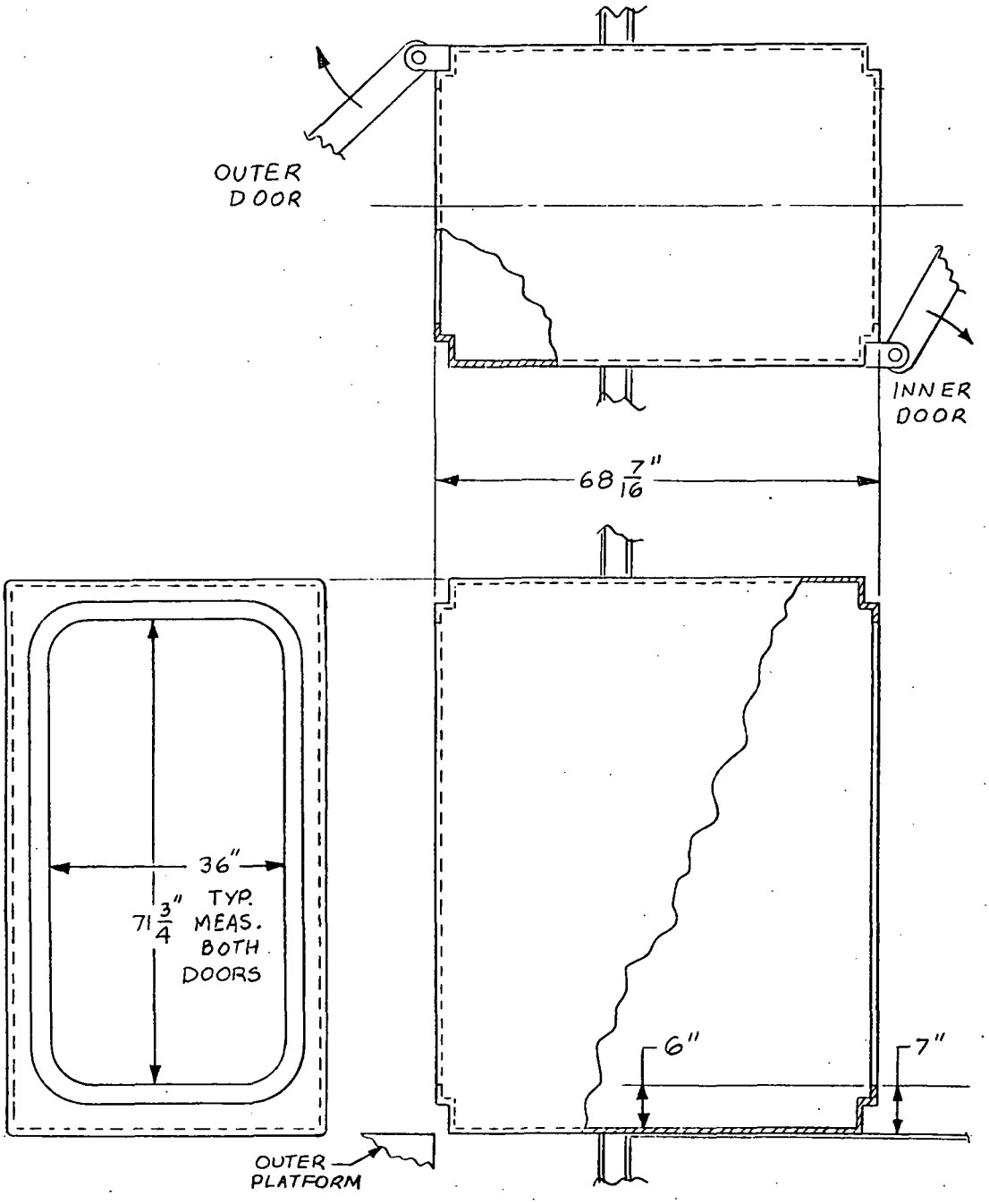


FIGURE 1. AIRLOCK DIMENSIONS

8.2 VFE Documentation

VFE designed specifically for the chamber shall be subject to the same documentation control as GFE (8.1). Complete documentation will not be required for off-the-shelf procured equipment (e.g., refrigerator, freezer, etc.). Vendor manuals and other vendor data will be referenced on the installing MDAC drawing as required for maintenance and operating information.

8.3 MDAC Documentation

8.3.1 In order to maintain the documentation, there must be a reasonable uniformity in the format and execution of the Engineering Orders (EO) and drawings. The use of mechanical schematics simulator the 90-day test drawings will be acceptable for the final unit drawing (8.3.9.1). In order to fabricate components or assemblies such as partitions, cabinets, bunks, tanks, etc., detail drawings or advance EO's (AEO) will be required, but formal release and QC will not be required. These drawings should contain minimum detail and may require some engineering coordination with the shop.

8.3.2 All unit drawings must be released and installations inspected by QC prior to completion of ORI. However, in order to expedite fabrication and minimize EO changes, the shop can work from sketches and preliminary drawings. The design can be accomplished in the following phases.

8.3.2.1 Phase I - Breadboard Design

During this phase the design configuration is determined and bench testing is conducted. Fabrication may be accomplished by informal sketches.

8.3.2.2 Phase II - Preliminary Design

During this phase the sketch are converted to preliminary drawings which are not formally released. Changes are made by marked prints. One marked print is retained by QC. The QC marked print will be the master copy.

8.3.2.3 Phase III - Final Design

During this phase the preliminary drawings are completed by incorporation of the marked changes and release through the Laboratory Release System (LRS). If the fabrication is complete, the releasing EO will state that this release is for "QC inspection per 1T33501". All subsequent changes must be made by the normal EO release process and copies provided to QC for configuration control. The final release must be initiated as soon as possible in order to provide QC with sufficient time to complete the final "buy-off" prior to ORI. A fabrication order (FO) will be prepared for the final "buy-off".

8.3.3 The normal LRS procedures will be used to prepare AEO's and drawings for release. Special instructions are noted on the example AEO in Figure 2. Prior to release, a blueline of the AEO must be placed in the master control book and identified with the appropriate change letter. When a released copy is received, the blueline will be removed and the released copy inserted. When the drawing is released, the releasing EO will be recorded in the same manner.

8.3.4 Place notes for fabrication and purchasing coordination on all drawings. For coordination, list the person most directly concerned and the Engineering Laboratory Test Coordinator. All release drawings for fabrication of structural components and detail assemblies shall carry the note: "No functional inspection required. Any functional acceptance to be accomplished by Engineering, A3-830, BBCO."

8.3.5 All components and materials shall be ordered on AEO's. If possible, the unit drawing should be used for all procurement within the unit. This will permit accurate tabulation of the list of material. If identical components or materials are to

ENGINEERING ORDER DOUGLAS AIRCRAFT CO., INC

FORM X25-509D-1 (REV 7-63) SANTA MONICA, CALIF CODE 18355

FIRM | OUTSTANDING AEO & SEO / LATEST RELEASED CHANGE | PREPRINTED DATE | SHEET 1 OF Y

TITLE: SAMPLE

DATE

DATE

DATE

DATE

DISPOSITIONS
1. FABRICATION EFFECTIVITY MUST CONFORM-ASSY/INSTAL USAGE OF CHANGED OR PRIOR PARTS ACCEPTABLE
2. PARTS MUST CONFORM AT NOTED EFFECTIVITY
3. REWORK AS NOTED
4. SCRAP
5. NOTED

EXTRA E.O: M.S. Bonura, A3-830
J.P. Valinsky, A3-270

ENGRG TIME CHG: *

EWO: *

WRO:

IPWO:

EXTRA E.O.
G.E. Hart, A3-273
F.A. Davison, A-730
D. Straw, A3-738

CUSTOMER:

CUSTOMER AUTH:

DESIGN SECTION: BBCO or AGC1

DWG TO BE MADE OR CHANGED: YES / NO

E.O. MADE BY	DESIGN APPROVAL	CHECK E.O.	STRENGTH	RELEASE & MATERIAL	FRI	DWG	TYPE	SLI	SUB	CA
Joe Doakes	**	***								
DWG MADE OR CHGD BY	PROJ ENGR	CHECK DWG	WEIGHT WA / WD	CHANGE CONTROL						

MODEL	SECTION	RELEASE S.O.	DISP NO	EFFECTIVITY FIRST	EFFECTIVITY LAST	EFFECTIVITY START OF CHG	EFF SYM	TABULATION	NEXT ASSEMBLY DRAWING NUMBER
Gen		*							

NOTES ON ALL EO's:

1. No receiving functional inspection required. Visual inspection only.
2. For further information contact Joe Doakes, A3-833, Ext. XXXX or J. P. Valinsky, A3-273, Ext. 3510.
3. Deliver to CB A3-275, Attention G. E. Hart, A3-273, Ext. 3614.

* Use appropriate charges. Capital Items, S.O. (TBD) EWO (TBD) Expense Items, S.O. (TBD) EWO (TBD)

** Signed by M.S. Bonura for BBCO and J.P. Valinsky for A3-273.

*** Use for coordination with medical or man-machine items. To be signed by J.S. Seeman or J. R. Wamsley, M.D., A3-830, as required.

FIGURE 2.

be procured for installation into more than one unit, use the number of the lowest common assembly or installation drawing that contains all the components or material.

8.3.6 Electrical wiring diagrams must be prepared for all Life Support Systems, instrumentation, monitoring equipment and emergency facilities. These diagrams must contain sufficient detail to permit trouble-shooting, circuit analysis and QC "buy-off". All terminal board attachments, connector pins and component attachments must be identified. Electrical schematics which do not identify all terminal connections, will be acceptable for non-critical facilities and facility power installations. Wiring diagrams and schematics will be released similar to 8.3.2.

8.3.7 Drawings for installations inside the chamber will include a list of materials for both mechanical and electrical drawings and shall identify only dynamic components (e.g., valves, solenoids, relays, motors, pumps, etc.). Bulk material need not be identified unless this material is considered questionable from an outgassing or combustible nature. The total quantity and identity of questionable materials shall be noted on the drawing. Drawings for facilities outside the chamber shall contain a limited list of components and sufficient detail to permit trouble-shooting and repair.

8.3.8 The following general notes shall be used as applicable on electrical drawing for installations inside the chamber, except where noted otherwise. In order to minimize drafting time, the drawing may contain the note: "General notes per 1T33501, paragraph 8.3.8." Any deviations or additional specifications shall be noted on the drawing.

8.3.8.1 Install wire and cables per the DPS 54000 series for inside and outside installations.

8.3.8.2 Use teflon-insulated wire or approved equivalent.

8.3.8.3 Use 7869679 teflon-jacketed wire or approved equivalent for all installations requiring shielded wire. Nylon-jacketed shielded wire is acceptable for outside instrumentation wiring only.

8.3.8.4 Use Tefglas tape (DPM 1833) for wire bundle ties. The nylon tape (DPM 731-2) is acceptable for outside installations only.

8.3.8.5 Replace all vinyl, nylon and neoprene-insulated power cords from vendor-furnished equipment with teflon-insulated wire when practical. If replacement is impractical, cover all exposed wire with teflon tubing or teflon tape (DPM 3001).

8.3.8.6 Use glass or teflon-coated instrumentation wire on all thermocouple installations. The nylon-covered thermocouple wire is acceptable for outside installation only.

8.3.8.7 Wrap plastic splices with teflon tape (DPM 3001).

8.3.8.8 Cover wire lugs (plastic or bare) with teflon heat shrinkable tubing as required.

8.3.8.9 When wire bundles are in an exposed area where there is a possibility that personnel might step on them, they shall be covered with a suitable metal shield.

8.3.8.10 Wire bundles shall be supported with NAS1715, NAS1713, or equivalent teflon cushion clamps. If teflon cushion clamps are unavailable, use bare clamps and wrap the bundle with teflon tape (DPM 3001) in the area under the clamp.

8.3.8.11 All equipment chassis shall be electrically bonded to the chamber structure with a maximum resistance on one ohm. Bond per DPS 52050 all faying surfaces to insure good electrical contact between equipment and chamber structure.

8.3.8.12 Install guards or barriers over all exposed contacts and terminals per MIL-STD-454B, Section 5.5.

8.3.8.13 Continuity checks must be made on all cables and electrical installations.

8.3.8.14 All 115 VAC equipment shall be wired with 7572G Hubbell twist lock connectors, or approved equivalent. Wire connectors as follows:

Large Brass - Chassis Grnd.
Small Brass - Neutral or return
Small Copper - Hot line

8.3.9 The following general notes shall be used as applicable on mechanical drawings for installation inside the chamber except where noted otherwise. In order to minimize drafting time, the drawing may contain the note: "General notes per 1T33501, paragraph 8.3.9." Any deviations or additional specifications shall be noted on the drawing.

8.3.9.1 37° flared type tubing and fitting, both inside and outside, shall be fabricated and installed per DPS 10001 and 10002, except the use of torqued wrenches and torque strips shall not be required.*

8.3.9.2 Teflon tape (DPM 2766) shall be installed on all pipe thread installed both inside and outside per DPS 44250. Do not use pipe compounds.

8.3.9.3 Install conical seals (S0254 or equivalent) on 37° flare fittings in the Coolanol-35 piping.

8.3.9.4 Coolanol -35 lines shall be insulated with Kaowool.

8.3.9.5 Wrap all insulated lines with aluminum tape (DPM 2918-1).

---

*NOTE: System leak test procedures shall be specified on the installation drawing or the AEO. All leak checks must be witnessed by QC.

8.3.9.6 Use Silastic 651 boots for all duct connections. Wrap boots with aluminum tape (DPM 2918-1).

8.3.9.7 Use RTV-1016 (DPM 2531) and RTV-731 (DPM 3201) silicone sealants only.

8.3.9.8 The use of plastics and other combustivles must be minimal. Questionable material which cannot be stored in metal containers must be covered with aluminum tape (DPM 2918-1), teflon tape (DPM 3001) or other non-combustible approved material.

8.3.9.9 Stainless steel, zinc or nickle-plated bolts should be used for attachments where feasible. Cadmium-plated bolts and components should be used sparingly. Cadmium acceptable only in areas below 250°F and shall not be used in water or food systems.

8.3.9.10 Stainless steel tubing and fittings must be used on all fluid and gas instrumentation sample lines. Aluminum tubing and fittings may be used in instrumentation pressure sensing lines. The use of copper tubing and brass fittings shall not be allowed for instrumentation lines.

8.3.9.11 Identify basic function and line content of all fluid lines with DPM 897 tape using the appropriate dash number and nomenclature as shown in Table 3. Identify flow direction with DPM 875 tape printed with flow arrow. Overlay with DPM 895 tape. Prepare and apply tapes per DPS 02052. The location of identification tapes shall be determined by engineering after installation.

TABLE 3

FLUID LINE IDENTIFICATION NOMENCLATURE

Tape DPM No.	Line Content Nomenclature	Tape Color
897-6	Hot Coolanol	Blue and Yellow
897-7	Carbon Dioxide	Orange
897-7	Hydrogen *	Orange
897-7	Nitrogen	Orange
897-7	Methane *	Orange
897-8	Sample Gas	Orange and Gray
897-8	Instrumentation	Orange and Gray
897-8	Vacuum	Orange and Gray
897-9	Cold Coolanol	Blue
897-10	Breathing Oxygen	Green
897-12	Firex	Brown
897-13	Water	Gray
897-16	Pneumatic Gas	Orange and Blue

* Also identify with DPM 897-14 Warning Tape

8.3.9 In order to maintain uniformity in the documentation, the following nomenclature and acronyms will be used in all drawings.

8.3.9.1 Life Support System Nomenclature

Waste Management Subsystem

- Commode Unit
- Urine Collector Unit

Water Management Subsystem

- Potable Water Recovery Unit
- Wash Water Recovery Unit

Atmosphere Control and Purification Subsystem

- Thermal and Humidity Control Unit
- Toxin Control Unit
- CO_2 Concentrator Unit

Atmosphere Supply and Pressurization Subsystem

- Sabatier Reactor Unit
- Electrolysis Unit
- Two-Gas Control Unit

8.3.9.2 Acronyms

LSS - Life Support System
LSM - Life Support Monitor
GAC - Gas Analysis Console
LSDS - Low Speed Digital Subsystem
CLSM - Crew Life Support Monitor
TSCL - Time Share Computer Link
TSCT - Time Share Computer Terminal
TGAS - Two Gas Atmosphere Sensor (Perkin-Elmer)
AMS - Analog Measurement Subsystem
PDS - Physiological Display Subsystem
ORIC - Operational Readiness Inspection Committee
ORI - Operational Readiness Inspection
ORR - Operational Readiness Review

9. QUALITY ASSURANCE

Functional checkout tests shall be performed on the integrated installation per NASA CR-111882, Section 14. The quality assurance shall be per NASA CR-111882, Section 2.4.

Appendix G

EXPERIMENTAL DESIGN AND COMPUTER ANALYSES OF BIOMEDICAL BLOOD AND URINE SAMPLE COLLECTION

Introduction

The objective of the experimental design and computer analysis is to provide a maximum amount of information to assist in the initial examination of the results of the blood and urine sample collection. In general, clinical symptomatology and medical legal considerations are assumed to be the motivation for the blood and urine tests. Diurnal recycling is also of interest.

From an experimental design point of view, the null hypothesis states there will be no significant changes in the results of the blood and urine tests due to the crewmen being exposed to test conditions.

The 90-day test demonstrated the advisability of using computer programs for the analyses of blood and urine tests. Computer programs have the capability of performing very rapid calculations requiring no human intervention beyond the setting up of the input deck and providing inexpensive analyses. Furthermore, many iterations to investigate particular areas of interest are possible using computer analyses.

Formatting the data for computer runs requires some preparation. However, if sufficient forethought is given to the procedure for collecting the input data, this time can be minimized. The results of the blood and urine tests can be entered directly onto load sheets from which punched cards can be generated. These load sheets can double as the permanent record of the blood and urine test results. It is critically important to coordinate with the Systems Analyst and/or the Programmer involved with designing the load sheet format.

Tests To Be Performed

Blood tests and urine tests are to be performed on the samples collected before, during, and after the 4-week manned test. Under the heading of blood tests, there are two subparts. They are Hematology and Biochemistries. Table 1 details these tests. They represent the minimum number of tests to be performed and by no means represent the final list. It will be noticed that the

Table 1

BIOMEDICAL ANALYSIS OF BLOOD AND URINE

TESTS TO BE PERFORMED

Blood Tests

A. Hematology (venous or cutaneous sample)
   1. Hemoglobin
   2. Microhematocrit
   3. White Blood Cell Count
   4. Red Blood Cell Count

B. Biochemistries - SMA-12 (10cc venous sample frozen for later analysis)
   1. Alkaline Phosphatase
   2. Bilirubin Total
   3. Uric Acid
   4. SGOT
   5. LDH
   6. Ca^{++}
   7. Inorganic Phosphorus
   8. Total Protein
   9. Albumin
   10. Blood Urea Nitrogen
   11. Glucose
   12. Cholesterol
   13. Albumin/Globulin

Urine Tests

Test for: (single sample or total urine volume for 24 hours)

1. Na^{+}
2. K^{+}
3. Cl^{-}
4. Ca^{++}
5. PO_4
6. Specific Gravity
7. Titratable Acidity
8. H^{+}
9. NH_3
10. ph

biochemistry test #13 is actually a ratio which is calculated from several previous tests; this calculation will be performed as the first step of the data analysis.

The ten urine tests are also called out in Table 1. These tests are performed on a single sample of the total urine volume for 24 hours.

Schedule of Sample Collection

For purposes of the biomedical analysis of blood and urine, the test period consists of a pre-manned test period, the manned test itself, and a post-manned test period. Each of these periods will be 28 days, or 4 weeks in length. The blood will be collected by means of venous sampling techniques during the three test periods, with one sample being collected each week.

For the urine analysis, a daily aliquot from the entire 24-hour output of each crewman will be used. The urine samples will be collected two weeks immediately prior to the manned test, during the entire manned test, and two weeks after the manned test.

Table 2 shows the schedule of sample collection for both the blood and the urine as it is presently planned.

There appears to be some doubt as to the optimum frequency of collection of blood samples. In order to determine what this frequency should be, a pilot experiment (not shown in Table 2) might be employed. This experiment would precede the pre-manned test period and would be designed such that blood would be collected every day for two or three samples a day. It is not necessary that crewmen be used in this pilot experiment; men of comparable age and stature would suffice. The results of the blood tests performed on the pilot experiment subjects would give an indication as to the kind of variation to be expected in the crewmen and would thus permit the best educated guess as to the optimum frequency of sample collection.

TABLE 2

BIOMEDICAL ANALYSIS OF BLOOD & URINE
SCHEDULE OF SAMPLE COLLECTION

PRE MANNED TEST

DAY →	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28
		WK 1				WK 2			WK 3			WK 4			
BLOOD (10cc Venous Sample) 8am		x		x		x		x	x		x		x		x
BLOOD (10cc Venous Sample) 4pm		x		x		x		x	x		x		x		x
URINE (Sample of 24-hr Collection)									x	x	x	x	x	x	x

Once/Day

MANNED TEST

DAY →	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28
		WK 1				WK 2			WK 3			WK 4			
BLOOD (10cc Venous Sample) 8am		x				x			x				x		
BLOOD (10cc Venous Sample) 4pm		x				x			x				x		
URINE (Sample of 24-hr Collection)		x	x	x	x	x	x	x	x	x	x	x	x	x	x

Once/Day

POST MANNED TEST

DAY →	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28
		WK 1				WK 2			WK 3			WK 4			
BLOOD (10cc Venous Sample) 8am		x		x		x		x	x		x		x		x
BLOOD (10cc Venous Sample) 4pm		x		x		x		x	x		x		x		x
URINE (Sample of 24-hr Collection)		x	x	x	x	x	x	x							

Once/Day

x = Sample Collection

Experimental Design for the Analysis of Blood Tests

The analysis of the blood tests will follow a 4-part procedure (illustrated in Table 3). The first operation to be performed on the raw data will be the preprocessing of the raw data. This will consist of the normalization of the data to accommodate the crewman body size if this is desirable for the specific blood test. Also, ratios of selected blood test scores can be constructed at this point. The second step in the analysis of the blood samples consists of computer-drawn plots of the preprocessed raw data. For 17 tests, 4 hematology tests and 13 biochemistry tests, 136 plots would be generated for 8 crewmen. The plots will enable the biomedical investigators to see unusual patterns in the raw data and to generate hypotheses about the interactions and causal effects of the manned test on the blood constituents. The axis of the plots will be the value of the test results, and the horizontal will be the collection day.

The third part of the experimental design consists of initial multiple correlations of the blood test results. These correlations permit the examination of patterns between the individual blood tests in order to determine which constituent varies with what other constituent. These correlations are thought of as initial correlations, with other correlations to be run based on the interpretation of the results of these initial computer runs. Since there are four ways in which the crewmen can be combined, that is, all eight crewmen, the inside and outside crew, the day/night divisions of the inside crew, and the total crew, by the four test periods, there are 16 total computer runs to be made.

A by-product of the multiple correlations is the descriptive statistics provided by the correlation program. These statistics consist of the mean value of each set of the test scores, the standard deviation of these values, and the range. These statistics should be quite helpful in the preliminary investigation of the results of the blood tests.

The fourth part of the experimental analyses consists of the initial analysis of variance. This design is illustrated in Table 3. Analysis of variance designs requires a factoral experimental design; a 4-dimensional factoral design is used. The four dimensions are: blood tests (hematology and biochemistries);

TABLE 3.

BIOMEDICAL ANALYSIS OF BLOOD AND URINE EXPERIMENTAL DESIGNS FOR ANALYSIS OF BLOOD TESTS

1. Preprocessing of Raw Data
   - A. Normalization (if desirable)
   - B. Ratio Construction
2. Computer Plots of Preprocessed Raw Data and Ratios
   - A. 17 tests x 8 crewmen = 136 plots
   - B. Plots are: test results by sample collected
3. Initial Multiple Correlation of Blood Test Results
   - A. Number of Computer Runs = 16

$Tests_{17}$ x CM_8

$Tests_{17}$ x Inside/Outside CM_2

$Tests_{17}$ x Day/Nite Inside CM_2

$Tests_{17}$ x Crew

PRE	MANNED TEST	POST	ENTIRE

Each elem represents one computer run

   - B. Statistics provided by correlation program for each run
     1) mean value of test sample
     2) standard deviation
     3) range

4. Initial Analysis of Variance Design
   - A. Tests x CM x Manned Test Period x Collection Time (one computer run)

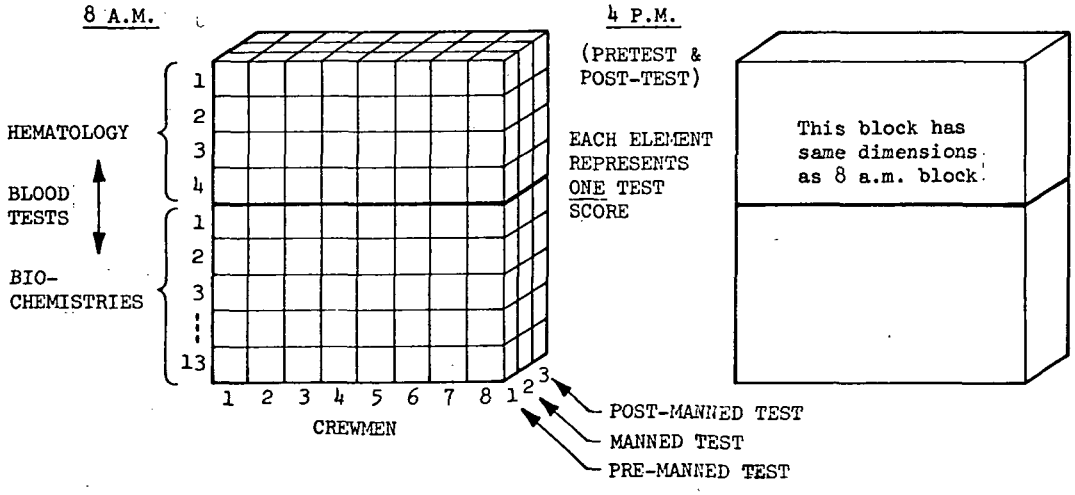
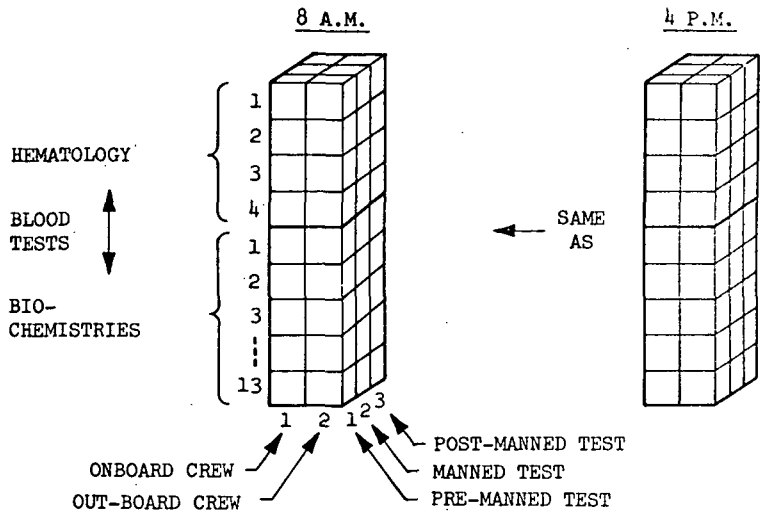


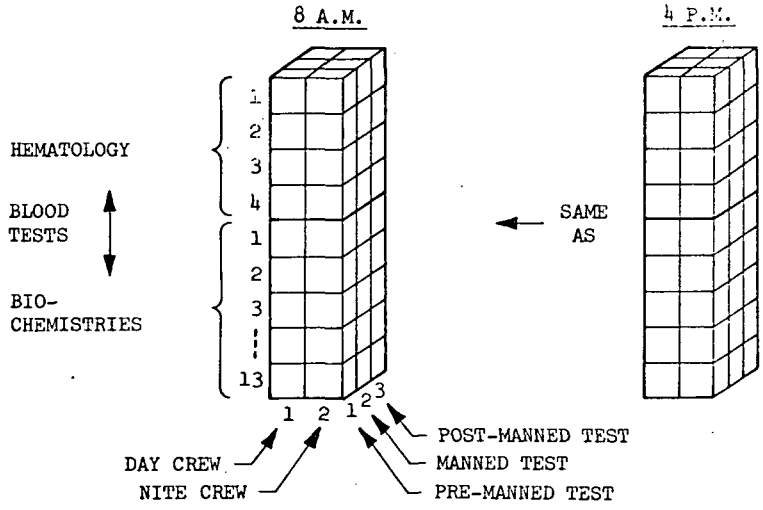
TABLE 3. (Continued)

4. Initial Analysis of Variance Design (Continued)

B. Tests x On-Out CM x Manned Test Period x Collection Time (one run)



C. Tests x Day-Nite CM x Manned Test Period x Collection Time (one run)



crewmen, eight in this design; period of the manned test; and time of day of collection. This single, 4-dimensional design represents one computer run, unless it is judged that the hematology and blood chemistries should be run separately. If this is the case, two computer runs will be necessary.

The second and third analysis of variance designs are also shown in Table 3 and are quite similar to the first design with the difference that in the second design the outboard crew and the onboard crew constitute the crew breakdown. In the last design, the day crew and the night crew constitute the crew breakdown of only the onboard crew. The remaining dimensions for these designs are the same as for the initial design explained. The comment about the possibility of the hematology and the biochemistries being two runs applies here also.

Experimental Design for Analysis of Urine Tests

The design for the urine tests follows, in general, the experimental design for the blood tests. The four subparts to the design (shown in Table 4) follow the four subparts mentioned above.

The first operation to be performed on the raw data, the scores of the tests, is the preprocessing step. This consists of normalization of the urine scores to body weight, as well as ratio construction of more complex indices of urine results.

Computer plots of the preprocessed raw data and ratios are the next item in the biomedical analysis of the urine tests. Eighty plots, computer generated, result from 10 urine tests of 8 crewmen. The plots are test results on the vertical axis, vs the day of the sample collected on the horizontal axis.

The initial multiple correlations of the urine test results follow the same pattern as the blood test correlation. Four types of combinations of crewmen by the four periods to be examined give 16 computer runs to generate the correlations. As before, descriptive statistics are provided by the correlation program for each of the 16 runs.

TABLE 4.
BIOMEDICAL ANALYSIS OF BLOOD AND URINE
EXPERIMENTAL DESIGN FOR ANALYSIS OF URINE TESTS

1. Preprocessing of Raw Data
   - A. Normalization to Body Weight
   - B. Ratio Construction
2. Computer Plots of Preprocessed Raw Data and Ratios
   - A. 10 Tests x 8 Crewmen = 80 plots
   - B. Plots: Test Results by Sample Collected
3. Initial Multiple Correlations of Urine Test Results
   - A. Number of Computer Runs = 16

$Tests_{10} \times CM_8$

$Tests_{10} \times$ Inside/Outside CM_2

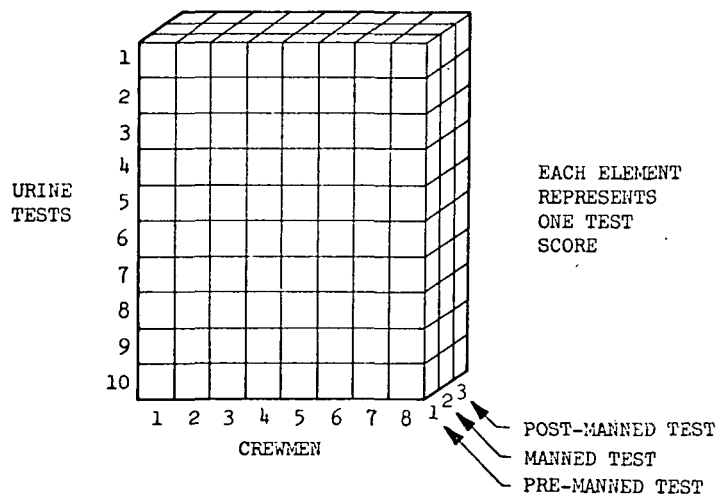
$Tests_{10} \times$ Day/Nite Inside CM_2

$Tests_{10} \times Crew_1$

PRE	MANNED TEST	POST	ENTIRE

EACH ELEMENT REPRESENTS ONE COMPUTER RUN

   - B. Statistics Provided by Correlation Program for Each Run
     1) Mean value of test sample
     2) Standard deviation
     3) Range
4. Initial Analysis of Variance Design
   - A. Tests x CM x Manned Test Period x Collection Time (one computer run)



The initial analysis of variance design is shown in Table 4. This is a 3-dimensional design with the results of urine tests, crewmen, and the manned test period providing the three dimensions. Each element in this design represents one test score, and the entire design is one computer run.

Concluding Remarks

The purpose of this Appendix is to explain an experimental design which yields the maximum information on the test scores for the blood and urine sample collection. Hopefully, it will be found that the null hypothesis cannot be accepted because of significant differences and pattern deviations showing up in the analyses. If this is the case, other analyses will have to be performed to further investigate the detailed discrepancies found in the data. The results of the initial analyses are a prerequisite to the design of these other and more interesting analyses.